NOTE

This Microfiche meets the quality requirements of the American National Standard for Microfiche of Documents (ANSI PH5.9-1975). However, because of imperfections in the document from which it was made, it contains images that are illegible or difficult to read. The source document for this microfiche is the best copy that could be obtained prior to filming.

CIS Congressional Information Service
Washington, D.C.

S HRG. 101-424

THE FUTURE OF THE U.S. SEMICONDUCTOR INDUSTRY AND THE IMPACT ON DEFENSE

HEARING

BEFORE THE

SUBCOMMITTEE ON
DEFENSE INDUSTRY AND TECHNOLOGY

OF THE

COMMITTEE ON ARMED SERVICES
UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

NOVEMBER 29, 1989

Printed for the use of the Committee on Armed Services

U.S. GOVERNMENT PRINTING OFFICE

24-892 WASHINGTON : 1990

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

S201-13

COMMITTEE ON ARMED SERVICES

SAM NUNN, Georgia, *Chairman*

J. JAMES EXON, Nebraska
CARL LEVIN, Michigan
EDWARD M. KENNEDY, Massachusetts
JEFF BINGAMAN, New Mexico
ALAN J. DIXON, Illinois
JOHN GLENN, Ohio
ALBERT GORE, JR., Tennessee
TIMOTHY E. WIRTH, Colorado
RICHARD C. SHELBY, Alabama
ROBERT C. BYRD, West Virginia

JOHN W. WARNER, Virginia
STROM THURMOND, South Carolina
WILLIAM S. COHEN, Maine
PETE WILSON, California
JOHN McCAIN, Arizona
MALCOLM WALLOP, Wyoming
SLADE GORTON, Washington
TRENT LOTT, Mississippi
DAN COATS, Indiana

ARNOLD L. PUNARO, *Staff Director*
PATRICK A. TUCKER, *Minority Staff Director and Counsel*

SUBCOMMITTEE ON DEFENSE INDUSTRY AND TECHNOLOGY

JEFF BINGAMAN, New Mexico, *Chairman*

ALBERT GORE, JR., Tennessee
TIMOTHY E. WIRTH, Colorado
ROBERT C. BYRD, West Virginia

MALCOLM WALLOP, Wyoming
TRENT LOTT, Mississippi
DAN COATS, Indiana

CONTENTS

CHRONOLOGICAL LIST OF WITNESSES

Ross, Dr. Ian M., president, AT&T Bell Laboratories and chairman of the National Advisory Committee on Semiconductors 3

Bromley, Dr. D. Allan, science adviser to the President and Director, Office of Science and Technology Policy, accompanied by Dr. Robert L. Post, Jr., Assistant to the Director, Office of Science and Technology Policy 72

McCormack, Robert C., Acting Deputy Under Secretary of Defense for Acquisition, Department of Defense 89

Noyce, Dr. Robert N., president and chief executive officer, Sematech 100

Kulicke, C. Scott, chairman of the board and chief executive officer, Kulicke and Soffa Industries, Inc 114

THE FUTURE OF THE U.S. SEMICONDUCTOR INDUSTRY AND THE IMPACT ON DEFENSE

WEDNESDAY, NOVEMBER 29, 1989

U.S. SENATE,
SUBCOMMITTEE ON DEFENSE INDUSTRY AND TECHNOLOGY,
COMMITTEE ON ARMED SERVICES,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:03 a.m., in room SR-253, Russell Senate Office Building, Senator Jeff Bingaman (chairman of the subcommittee) presiding.

Committee members present: Senators Bingaman, Gore, and Lott.

Professional staff member present: William H. Smith.

Minority staff members present: Patrick A. Tucker, minority staff director and counsel; Romie L. Brownlee, deputy staff director for the minority; Jonathan L. Etherton and George W. Lauffer, professional staff members.

Staff assistants present: Mary J. Kampo and Melissa A. Ramsey.

Committee members' assistants present: Edward M. McGaffigan, Jr., assistant to Senator Bingaman; Leon S. Fuerth, assistant to Senator Gore; Jefferson B. Seabright, assistant to Senator Wirth; Charles G. Pearcy, assistant to Senator Lott; and Eric H. Thoemmes, assistant to Senator Coats.

STATEMENT OF SENATOR JEFF BINGAMAN, CHAIRMAN

Senator BINGAMAN. We will call the hearing to order.

This is a hearing of the Defense Industry and Technology Subcommittee. Our main focus is to hear about the report of the National Advisory Committee on Semiconductors.

The National Advisory Committee on Semiconductors was created in last year's Omnibus Trade Bill. It was charged with developing a national strategy to assure the continued leadership of the United States in semiconductor technology. Its report, entitled "A Strategic Industry at Risk," contains a summary of the current state of the semiconductor industry as well as numerous recommendations on actions that should be taken. These recommendations provide a framework for a national semiconductor strategy.

We are very pleased to have with us today Dr. Ian Ross, chairman of the National Advisory Committee on Semiconductors, to go through the report with us.

The advisory committee was created because of the recognition by Congress of the importance of this semiconductor industry to national security and economic prosperity. At the same time Con-

gress laid out the guidelines for Federal participation in SEMATECH, the semiconductor manufacturing technology consortium. I firmly believe that SEMATECH has proved to be a successful investment for the Federal Government, and fortunately, today, we have Dr. Robert Noyce, the President of SEMATECH to give us a progress report and discuss other items in this report.

When SEMATECH was created, it was clear to all involved that it alone would not be enough to save the U.S. semiconductor industry. An overall national semiconductor strategy would be needed. In fact, the 1987 report on defense semiconductor dependency by the Defense Science Board, the same report that recommended the establishment of SEMATECH, also recommended the creation of a government, industry, and university forum for semiconductors. The National Advisory Committee is in many ways an outgrowth of that report.

Semiconductors are important, and their importance is, I am sure, self-evident to anybody in this room. Not only do they give us access to the information age, but they are the underpinnings of many technologies. For example, in New Mexico we have significant employment by INTEL, by Signetics, by Motorola, and that employment extends in many other States as well.

One of the concepts that has been used to explain the role of semiconductors and other components is the so-called electronics food chain, and there is a reference to this in the report, which I am sure Dr. Ross will go into in some detail.

We also have a chart which we are going to put up here as the testimony goes forward which will better describe the electronics food chain. As we get into that, I hope we can try to relate the problems of semiconductors to this semiconductor chart.

I am concerned, as I am sure many others are here in Congress, about recent reports of attempts by administration officials to drastically reduce or eliminate funding for a number of existing Department of Defense programs such as SEMATECH, MANTECH, X-ray lithography, research support, High Resolution Display Technology research and other DOD critical technology programs.

This year Congress gave strong support for each of these programs. None were cut. We added funds in several cases. I believe the Department of Defense has an appropriate role in supporting research in long-term high-risk and high-potential technologies which are both military and dual use.

The private sector, which faces high capital costs and markets that demand very short time horizons and quick payoffs, cannot adequately support research in these areas. These programs are important to meet national security and economic challenges, and I am sure we will look very closely at the budget that we receive in January to determine how well supported they are.

We have a very distinguished set of witnesses today. As I mentioned earlier, first we have Dr. Ian Ross, who is the President of AT&T Bell Laboratories and chairman of this advisory committee.

The second panel will include Dr. Allan Bromley, who is the Science Advisor to the President and Director of the Office of Science and Technology Policy. We also have Robert McCormack, who is here from the Department of Defense.

Finally, in our last panel we have Dr. Robert Noyce, President of SEMATECH, and Mr. C. Scott Kulicke, Chairman and CEO of Kulicke and Soffa Industries, Inc., a semiconductor equipment manufacturer, who is representing the Semiconductor Equipment and Materials Institute here today.

Dr Ross, why don't you go ahead and make your presentation, describe your report in whatever detail you feel is appropriate. Then we will have some questions.

Before you begin, let me say that my colleague Senator Gore just came in. Perhaps he would like to make some opening statement before you begin your presentation.

Senator GORE. Mr. Chairman, I want to congratulate you on scheduling these hearings. I look forward to the witnesses' statements today.

I think the subject is an extremely important one. This Nation must remain competitive in semiconductors. This is true not only because of the national defense implications, but because of the implications for our ability to remain competitive as a nation in the industries that will dominate world commercial activity in the 21st century.

I personally believe that we are currently taking an extremely shortsighted view of the future. I think we must be much more active in identifying, supporting and encouraging those key portions of the electronics industry that have leverage over the future.

I look forward to learning from the witnesses today what their ideas are about what I believe is an extremely important subject where the country is concerned. Thank you, Mr. Chairman.

Senator BINGAMAN. Thank you very much.

Dr. Ross, we are very pleased to have you. Why don't you go ahead with your presentation.

STATEMENT OF DR. IAN M. ROSS, PRESIDENT, AT&T BELL LABORATORIES AND CHAIRMAN OF THE NATIONAL ADVISORY COMMITTEE ON SEMICONDUCTORS

Dr. Ross. Thank you, Mr. Chairman.

I personally appreciate the opportunity to testify today as Chairman of the National Advisory Committee on Semiconductors.

I have written testimony for the record, and attached to that is the full committee's report.

With your permission, what I will do now is report briefly on what the committee is, what our findings are, and what our recommendations are.

As you pointed out, we were created by the Omnibus Trade Bill just about a year ago. The committee is a national committee with eight industry members and five Government members, and we are advisors to the President and to Congress. It is in that advisory role that we appear today.

We were appointed by the President and had our first formative meeting in January of this year. We had our first working meeting in March of this year.

We organized ourselves into three working groups, each chaired by a committee member. One group looked at the environment in which the industry operates, another looked at the markets for

semiconductors domestically and worldwide, and one group looked at the technology that supports the semiconductor industry. Our report is based around those three approaches.

The legislation required the committee to submit a report annually at about this time, and what we have submitted is our first annual report. It is not a final report. It was timed by the requirements of the legislation. I think that was a very healthy requirement because it caused us to get our findings out early and to put out some recommendations. We will be the first to admit that we have further work to do.

But these are our interim recommendations and this is not a final report.

Summarizing our findings, we first recognized the strategic nature of the semiconductor industry.

Senator Bingaman, you referred to that. The semiconductor industry underlies the electronics industry.

Worldwide, the semiconductor industry is a $50 billion business. But it is the lifeblood of the electronics industry which, worldwide, is $750 billion. In this country, the electronics industry supports 2.6 million jobs.

But not only does it support the electronics industry, it touches almost anything we do, whether it is medical equipment, navigation, weather prediction, entertainment, and, as you mentioned, defense.

Indeed, the semiconductor industry is key to national defense. We rely on superior electronics to deal with numerical superiority of our potential enemies. So this is a key industry to national defense.

It is also an important driver of technology, both in industry and in academia.

For example, the preparation techniques of super-pure materials required by the semiconductor industry are also used more broadly. Computer aids to design is an important industry-wide technology, and the semiconductor industry stimulates research in the physical sciences, whether it be in industrial laboratories or in academia.

The second issue we looked at was the evidence for decline in the semiconductor industry. If I may, I would like to show you a viewgraph which shows four of the figures from the report of the committee.

[Viewgraph.]

The point I really want to make with these viewgraphs is the direction in which those lines are going. The trends are all in the wrong direction.

The first chart in the top left-hand corner shows the United States' market share, the black curve going down, versus the share of Japan, the red dotted line going up.

What it shows is that the United States' share went from over 60 percent in 1980, to less than 40 percent per year, and the Japanese share today is now about 50 percent.

The bottom left-hand corner shows the similar share for dynamic random access memory chips. You can see that we started out with a 100 percent share in the United States and it is now down below 20 percent, and the Japanese, with the red curve, are, at the moment, approaching 80 percent of the critical market.

The bottom right-hand curve, which is figure 4 in our report, shows in the red dotted line, again, the research and development spending for the top five Japanese firms, compared to the R&D spending for the equivalent five U.S. firms.

Although you see that the spending on R&D in the United States is increasing, the rate is much more rapid in Japan, by about a factor of two on that chart.

Senator BINGAMAN. Let me just interrupt for a moment. That chart shows in 1985, a dramatic upturn in Japanese research and development related to semiconductors. Is there a particular reason for that?

Dr. Ross. You could also say that in 1985 there was a little jog down. I don't know of any significant event that took place in 1985. I think the important thing is the very rapid increase in the Japanese investment in R&D, compared to what we are able to do.

Senator GORE. If I could seek a clarification on the same graph, you have limited the numbers to the total of the top five commercial firms in each country.

To what extent is the Government spending a distortion of the true picture?

In other words, DARPA's spending would not be reflected in the black line at the bottom, would it?

Dr. Ross. That is correct, nor would the equivalent Japanese Government spending in support of their industry.

Senator GORE. Would that roughly even out?

Dr. Ross. I don't know the answer to your question. I could try to get it for you.

Senator GORE. All right.

Dr. Ross. The final chart, on the top right-hand corner, which is figure 6 in our report, shows the leading producers of metal oxide semiconductor devices, which are really at the leading edge of much of what is going on. What it demonstrates in the period 1973 to 1988 is a trend from the U.S. being the leading providers or producers of MOS with some Japanese participation, to today, where the chart is dominated, in 1988, by Japanese firms and again, you see the trend.

Now the point I would like to make on all of this is that the United States' position in chip manufacturing is of concern. But what is of much more concern is that all of these trends are in the wrong direction and that we see nothing that is going to guarantee that these trends will turn around.

If you look at the semiconductor manufacturing equipment and materials industry, which is the supplier of the technology to this industry, it is even more severe. The curves are all heading in the same direction.

Our feeling is that unless something is done about the erosion of that industry and done within the next 2 or 3 years, we could find ourselves in the United States a generation behind our Asian competitors in the underlying technology, underlying equipment that is necessary for the industry.

So, although we see the chip industry problem to be very, very severe, the greatest urgency is in the semiconductor manufacturing and equipment industry and, wisely, you will have some testimony on that today.

So, that is our evidence for decline.

Now, what are the root causes? Let me say very briefly what we see those to be.

We looked at the industry environment and as we identify the one biggest concern we have there, it is the cost of capital. You can argue, and people do argue, as to what is the precise cost of capital to U.S. industry, compared to Japanese industry. But the general consensus is that it is higher in the United States and probably higher by about a factor of two.

That certainly affects one's willingness to invest in longer-term, more risky, enterprises.

As far as the market is concerned, which is our second thrust, we identified as a major problem the loss of markets in the United States in the electronics industry, and particularly in consumer electronics. As is obvious I think in our offices and homes, the consumer electronics industry has almost totally left the United States.

Today, that industry worldwide supports or buys about $11 billion of semiconductor product, and only $1 billion of that, or a little less, is supplied in the United States.

The consumer electronics industry is growing, and it is also becoming a driver of the leading edge of technology.

So, for both of these reasons, we feel that the loss or unavailability of a domestic consumer electronics industry is a root cause in the difficulties of the semiconductor industry.

Finally, when we look at technology, the main cause we see there is that we in the United States were late in embracing the concept that cooperation among industry and government in the precompetitive phases of technology is something that is beneficial.

Now, SEMATECH is probably the first example of putting together a cooperation in that precompetitive phase. And, as you said, Senator, it appears to be working very well.

The Japanese have embraced this concept in their own way, much earlier than we did, and we feel that our lateness in doing that has aggravated the situation, particularly in the semiconductor manufacturing and equipment environment.

Now, the recommendations of our committee again are based around these broad fields. We have recommendations on trying to reduce the cost of capital, on improving education, on intellectual property laws, on trade laws, and on antitrust.

These I think are recommendations that you've heard before from almost anybody that has looked at U.S. industrial competitiveness. There is really nothing unique in what we are recommending here. But we feel that these are very important things that we must reemphasize.

In the market arena, we are proposing, for consideration, a consumer electronics capital corporation that would be a privately owned but government encouraged corporation, with the objective of providing low cost, patient capital to any industry that wants to repatriate the consumer electronics industry.

Accompained with that, we feel it is necessary to assure a level playing field with people overseas, in terms of access to technology licensing, issues of local content, foreign manufacturers working here, local R&D and reciprocal access to markets.

We also, as part of our marketing recommendations, are recommending the encouragement of the deployment of a fiber-optics network with fiber into the residents, and the underlying motivation here is to expand the markets for equipments, for consumer electronics types of equipments, that would hang on the end of that network.

Finally, in the technology field, one of our suggestions is that we should enhance the mission and the funding of SEMATECH for R&D in this very critical SM&E industry.

Those, then, in very capsule form are our recommendations.

I would just conclude by saying that the problem is serious and the problem is getting worse; that what we are doing now is not working; and that the Nation needs some action to halt this erosion and hopefully to turn it around.

I appreciate the opportunity to be here today.

Thank you, gentlemen.

[The prepared statement of Dr. Ross along with the final version of the NACS report, "A Strategic Industry at Risk," follows:]

PREPARED STATEMENT OF IAN M. ROSS, PRESIDENT, AT&T BELL LABORATORIES AND CHAIRMAN OF THE NATIONAL ADVISORY COMMITTEE ON SEMICONDUCTORS

Mr. Chairman and Members of the Subcommittee:

I am pleased to appear before this Subcommittee today to urge timely action by industry and government to arrest the deteriorating global position of the U.S. semiconductor industry.

At the outset, I would like to note that I'll be speaking today as Chairman of the National Advisory Committee on Semiconductors (NACS). I also am President of AT&T Bell Laboratories. This Committee was established by Congress to devise and promulgate a national strategy for revitalizing our semiconductor industry. A working group, headed by a Committee member, has been formed to examine each of three major areas of critical interest: Business Environment, Market, and Technology. With the help of Government officials, industry executives, researchers, economists, and scholars, we have worked diligently to identify and assess the problems in these areas, and to make a report on those efforts, with our conclusions and recommendations. The first report of the Committee has been released and a copy of it is attached to this statement. I will be discussing the Committee's analysis of problems facing our domestic semiconductor industry and our recommendation of initial "first steps" for addressing these problems.

The semiconductor industry, as the foundation for all electronics-based industries, is of major strategic

importance to the United States, both economically and militarily. Consumer products, computers, telecommunications, military equipment, and other industries with products incorporating electronics are largely dependent upon the semiconductor industry. The semiconductor industry was invented and developed by American industry, and was dominated by U.S. firms for three decades. But, during this present decade, Japanese companies, with coordination and encouragement from their government, have aggressively expanded their semiconductor industry into a dominant position in the world marketplace for semiconductors. Furthermore, as a result, world leadership in several critical areas of semiconductor manufacturing technology has tended to shift to Japan. Firms that deal in semiconductor materials, manufacturing equipment (SM&E) and related instrumentation are being hurt by a shrinking supportive market in the U.S. and have lost a significant share of their market. Research and development also is being hurt. The top five Japanese semiconductor firms outspend their U.S. counterparts on R&D by a factor of two. This difference in R&D effort will accelerate future losses in our share of the world semiconductor market unless we can improve the way we approach achievement of technological progress.

THE SEMICONDUCTOR INDUSTRY'S NATIONAL ROLE

With extremely complex manufacturing processes, the very simple and common raw materials of sand, water, and aluminum, are transformed into the most intricate devices ever made by man. Millions of microscopic components for channeling electron flows are contained in a single

integrated chip that functions in a few billionths of a second. Silicon chips the size of your fingernail soon will contain a billion components and will perform more functions in less time than do their predecessors. Exceedingly expert levels of scientific and engineering knowledge are needed for these technological achievements. Demands for improved technologies in the semiconductor industry produce advances in many technical fields, like chemistry, physics, materials science, electrical engineering. The resulting gains in these and other fields of the physical sciences spill over to other industries and enhance our overall technical capabilities in this country.

The manufacturing capabilities of many industries are directly linked to the use of semiconductor chips. Improvements in chip technology thus directly enhance production capabilities in other industries. Purer chemicals and materials, more powerful computer-aided engineering and design, computer-integrated manufacturing - all promoted in the microelectronics industry - find broad applications in other industries, such as computers, communications products, and consumer products widely used throughout America. Furthermore, many of the manufacturing tools essential for achieving increased productivity, lower costs, and higher quality in industrial production are products of the semiconductor industry. Leadership in semiconductors can result in leadership in many industries.

2.6 million American jobs, more than double the jobs in America's steel and auto industries combined, depend upon the world market for electronics products. The $750

billion world market for such products is leveraged by the $50 billion world chip industry. Increased demand for consumer products, resulting from improvements in their cost and performance, prompts the producers of consumer products to support development of more advanced chip technology to further improve performance and cost and, thereby, further increase demand for their products. Thus, successful makers and sellers of electronics products like computers, microwave ovens, televisions, anti-lock brakes, and phone systems, demand innovation from the semiconductor industry.

The national security of the U.S. also is directly related to our industries' excellence in semiconductors. It is recognized that our and NATO's forces rely on a technological edge traceable to semiconductors to offset numerical superiority of potential adversaries. Unfortunately, that technological edge may soon depend upon foreign sources for leading-edge technology.

Two major business segments make up the semiconductor industry. Semiconductor manufacturers actually producing silicon chips comprise one segment. They make finished wafers from simple, but very pure, raw materials in expensive, ultra-clean manufacturing facilities. Also, the marketing, sales, packaging, testing and product support essential to their success is provided by these firms. The other segment, the semiconductor materials and equipment (SM&E) firms, produce the raw materials and manufacturing equipment needed for the production of integrated circuits. These SM&E firms are critical to the infrastructure essential to the overall microelectronics industry. They are

responsible for the set of tools and materials, used by most manufacturers, that enables the efficient, low-cost, high quality manufacturing of semiconductor chips. The chip and SM&E industries of the United States have both suffered serious declines in their share of the world market in this decade.

MANUFACTURING DECLINE

Over the past decade, Japan has taken over market leadership in the world from the U.S. merchant semiconductor industry. In 1980, the United States enjoyed more than double the worldwide market share of its nearest competitor, Japan. We dominated that market. But, by 1986, we were passed by Japan, and, by the end of last year, more than 50 percent of the world market belonged to Japan. Our share had dropped below 40 percent. We experienced market share losses not only in the well publicized leading-edge VLSI chips, but also in very simple high volume chips containing only a few transistors. The relatively equal 40 percent market positions of Japan and the U.S. for discrete devices in 1980 has now deteriorated to a less than 30 percent share for the U.S. and a more than 50 percent share for Japan. Discrete devices are of major importance both to military hardware and to many consumer products.

Maintaining a leading-edge chip technology becomes more expensive with each successive technological generation. Among all types of American industry, chip producers are at the forefront of annual investment (as a percentage of total revenues) in research and development, and in new plants and facilities. The cost of one state-of-the-art facility for

semiconductor memory chips has risen eight-fold since 1980, from $25 million to $200 million. Further increases are expected over the next several product generations, raising the cost for state-of-the-art manufacturing facilities to between $500 million and $750 million. The American semiconductor industry, during this last year alone, spent around $3 billion on R&D, and another $3.5 billion in capital investment. The resources of even very large firms are strained by such expenditures.

Even with such high investment rates compared with other American industries, our semiconductor industry is being outspent by our major Japanese competitors. The top five Japanese firms spend nearly twice as much on both R&D and new plants and facilities as is spent by the top five American firms. Increased revenues from an increased world market share are reinvested by the Japanese firms and account for much of this difference in spending. Japanese semiconductor revenues multiplied by a factor of six from 1981 to 1988, while revenues of U.S. producers merely tripled. This huge growth in the sales revenues of the top Japanese firms is funding an impressive level of investment in R&D and capital equipment with which to support further growth in Japan's share of the world semiconductor market.

Loss of market position by U.S. firms is equally apparent for key products, such as integrated circuit memory chips. Japan had a zero share of the market when the first integrated circuit memory was sold in 1970. Since then, Japan's share of the world market for memory chips had grown to 80 percent in 1988. This is particularly significant

since technical improvements over a broad range of process and manufacturing technologies applicable to other semiconductor products are driven by leading-edge memory technology., The loss in world market position by U.S. chip producers has seriously affected America's position in many important areas of semiconductor technology, especially in relation to Japan. We are holding our position in only a few areas. Technological knowledge is cumulative. Once lost, it is exceedingly difficult to regain.

MATERIALS AND EQUIPMENT (SM&E) INDUSTRY DECLINE

Driven mostly by memory device technology, the semiconductor industry pursues ever finer design rules. Device features have reached the submicron level, i.e., less than 1/50 the diameter of a human hair. Eighty-five percent of all leading-edge manufacturing capacity for submicron wafers is now in the Far East. This has been very detrimental to parts of the SM&E industry in the U.S. because large foreign chip producers prefer to work with their local SM&E suppliers, which they can control. Such close working relationships result in synergistic equipment advances by the foreign SM&E firms as they work at the leading-edge of technology with local chip producers. The previously commanding market share of America's SM&E firms that produce lithography equipment, test equipment, and materials, has deteriorated significantly. Although our SM&E firms dominated in the early 1980's as worldwide suppliers, the market is now dominated by Japanese firms.

CONSEQUENCES TO AMERICA

I believe that the evident decline of the semiconductor and SM&E industries in the United States is unacceptable. It is essential that we have a microelectronics industry that is locally based, locally controlled, and incorporates a full complement of leading-edge activities ranging from research and development through production, with costs, quality, and performance second to none. Neither imports nor foreign direct investment can, for the foreseeable future, allow America to receive the same level of benefits - military, technological, or economic - that an American microelectronics industry can provide.

The consequences are perhaps best seen from the perspective of national security. The qualitative edge in advanced weaponry and other military hardware underlying our strategic position should not depend on foreign trade flows that can be disrupted, and should not depend on foreign-owned manufacturing, even if it is physically based in the U.S.

Without a healthy semiconductor industry in the U.S., foreign competitors would have the leverage to control the flow of economic gains from microelectronics to the rest of our economy. Our foreign competitors, particularly the Japanese, have demonstrated their ability to cooperate so as to exercise market power and control both the access to and the price of critical technology. Our supercomputer companies have been unable to purchase the fastest foreign chips. The majority of American chip producers cannot get access to the most advanced foreign semiconductor

manufacturing equipment and materials on a timely basis. Remember the shortage of Dynamic Random Access Memory (DRAM) chips? American industry has lost control in many of these areas.

CRITICAL FACTORS

Foreign and domestic business policies and practices competitively detrimental to American industry; lack of full government support in the American business environment; shifts in markets for electronics products causing reductions in the markets for U.S. semiconductors; technological problems in the domestic electronics industry: all of these are factors contributing to the loss in world position suffered by the U.S. semiconductor industry.

The comparatively high cost of capital in the U.S. seriously disadvantages American semiconductor firms in competing effectively with Japanese semiconductor firms. It generally is agreed that capital costs in Japan are significantly lower than are capital costs in the United States. This is very significant to the availability of capital investment for expanding domestic industrial capacity, as the Japanese semiconductor industry did heavily early in the 1980s. It is important that the availability, cost, and patience of capital investment in U.S. industry be improved. Lower risk in investment decisions, longer time considerations for operations, and increased immunity from business cycle changes are advantages which result within a low cost and patient capital investment environment.

Electronics systems provide the major market for semiconductor chips. Production of these systems is migrating to the Far East, carrying the chip market along with it. In fact, by 1984, Japan had supplanted the U.S. as the world's largest semiconductor market.

Even more significant is the shift from America to Asia of the major part of consumer electronics production. Consumer electronics products, like televisions, radios, and VCRs, are one of the fastest-growing segments of the world market for semiconductors. As such, consumer electronics is a major contributor to research and development in semiconductor technology. Loss of a U.S. controlled consumer electronics industry has contributed to the decreasing ability of American semiconductor manufacturers to compete successfully with their foreign counterparts. Consumer electronics has become an effective driver of advanced semiconductor technologies, manufacturing techniques, and product costs. American electronics manufacturers have been pushed to the fringes of the critical world consumer electronics markets. They are hard pressed to sell into foreign electronics markets.

Another factor which has hurt America's semiconductor industry is its failure, until recently, to pool its research and development resources into cooperative precompetitive research efforts. The industry needs a long-term perspective if it is to stay at the leading-edge of technology. High quality technology through steady incremental improvements is needed, along with an understanding that technical knowledge is cumulative over

many product generations. Years before any resulting products are marketed, heavy precompetitive investments must be made in people, technology, and facilities. Major generations of processes are started five or more years before marketable product generations result. Major product generations usually are introduced about every three years. Thus, a semiconductor firm must bear concurrently the costs of at least two precompetitive efforts. This strains the financial resources of even the largest firms in the industry. Having recognized this problem for some time, Japanese firms regularly cooperate in precompetitive research, with substantial government involvement and assistance. The only comparable American effort is SEMATECH, a consortium of U.S. firms dedicated to improving semiconductor manufacturing technology.

Our foreign competitors also enjoy more supportive industrial policies and practices than do U.S. firms. Closed domestic markets and government subsidies contribute to a more supportive business environment in some foreign states. The rights U.S. firms have in their intellectual property often are difficult to enforce overseas, thus disadvantaging our companies in competing with foreign firms. Similarly, foreign chip producers often engage, with government sponsorship, in cooperative and coordinated behavior that would not be pursued in the U.S. under existing antitrust laws. Such behavior includes cooperative research and development, concerted pricing arrangements and captive customer and distribution arrangements through, e.g., vertical integration and cross-ownership. A business environment with the full support of government is needed in

the U.S.

The semiconductor industry must have well-trained workers, engineers and managers. Competitive performance of this industry is highly dependent upon the quality of its work force. Measures are needed across the entire spectrum of education in the U.S., from pre-schoolers to graduate students, so as to produce the well-educated workers we need. They must be able to adapt to new technologies and be sufficiently flexible to respond quickly to increasingly sophisticated and demanding work environments, such as that of the semiconductor industry. The degree of illiteracy among American adults is a national disgrace and severely handicaps our work force. Our universities have emphasized theoretical disciplines compared to practical manufacturing training. Additional emphasis must be placed on training in manufacturing engineering, and courses are needed to support advanced applications of total quality control. In addition, government action should be taken to enlarge the U.S. population of highly qualified scientists and engineers with advanced degrees.

RECOMMENDATIONS: TOWARD A NATIONAL SEMICONDUCTOR STRATEGY

Timely industry action, supported by government, is required to arrest the deteriorating global position of the U.S. semiconductor industry. Industry and government must cooperate, with each providing its special strengths and acting in its appropriate role. The National Advisory Committee on Semiconductors has developed recommendations that serve as initial steps towards the development of a comprehensive national semiconductor strategy. These initial

recommendations are:

1. Re-establish a fully competitive and supportive business environment in the United States to enable the U.S. semiconductor industry to operate on an equal footing with its major international competitors by:

   a. Promoting capital formation;

   b. Improving the education system;

   c. Reforming trade law;

   d. Protecting intellectual property; and

   e. Improving the antitrust climate.

2. Expand the U.S. industry's global semiconductor market share by rebuilding a strong U.S. position in the growing high-volume, high-technology electronic systems market by:

   a. Building a supportive business environment. There are several inseparable actions that must be implemented as a unit to accomplish this:

      · Establishing a for-profit Consumer Electronics Capital Corporation (CECC) to resurrect the U.S. consumer electronics industry infrastructure by providing a

multi-billion dollar pool of very-patient, low-cost capital;

- Urging the President to direct the appropriate agency to determine those factors which reduce the likelihood of a successful U.S. consumer electronics industry. Redress shall then be immediately sought through cooperative agreements (with non-U.S. corporations), consumer electronics technology licensing, local technology content minimums, and local R&D and design (or any combination of the preceeding); and,

- Having the Federal Government encourage and purposefully support the re-entry for the U.S. consumer electronics industry and its potential to compete vigorously. Accordingly, the Office of the U.S. Trade Representative shall ensure that access to the U.S. consumer electronics market shall be contingent upon reciprocal opportunity for U.S. companies to access foreign markets.

b. Providing expanded market opportunities by encouraging private industry to accelerate the development of a nationwide broadband network providing fiber-optic cable to the home, by modifying regulatory policy where necessary

and broadly experimenting with prototype and trials.

3. Enable the U.S. semiconductor industry to retain an enduring world-class, competitive technology position with a healthy semiconductor manufacturing equipment industry by:

a. Accelerating research and development in the U.S. semiconductor materials and equipment industry by expanding the mission SEMATECH, the semiconductor manufacturing technology consortium, in this area. SEMATECH's funding should be increased immediately by $100 million, half of which should be provided by the industry. Additional funding of $800 million will be required over the next 3 years for these programs fully to address the needs of this industry segment.

b. Sustaining the current Departments of Defense (DOD) and Energy (DOE) funding of $200 million per year that was previously allocated to very-high-speed integrated circuits and direct it toward maintaining long-term industrial R&D efforts related to silicon technology and manufacturing tools.

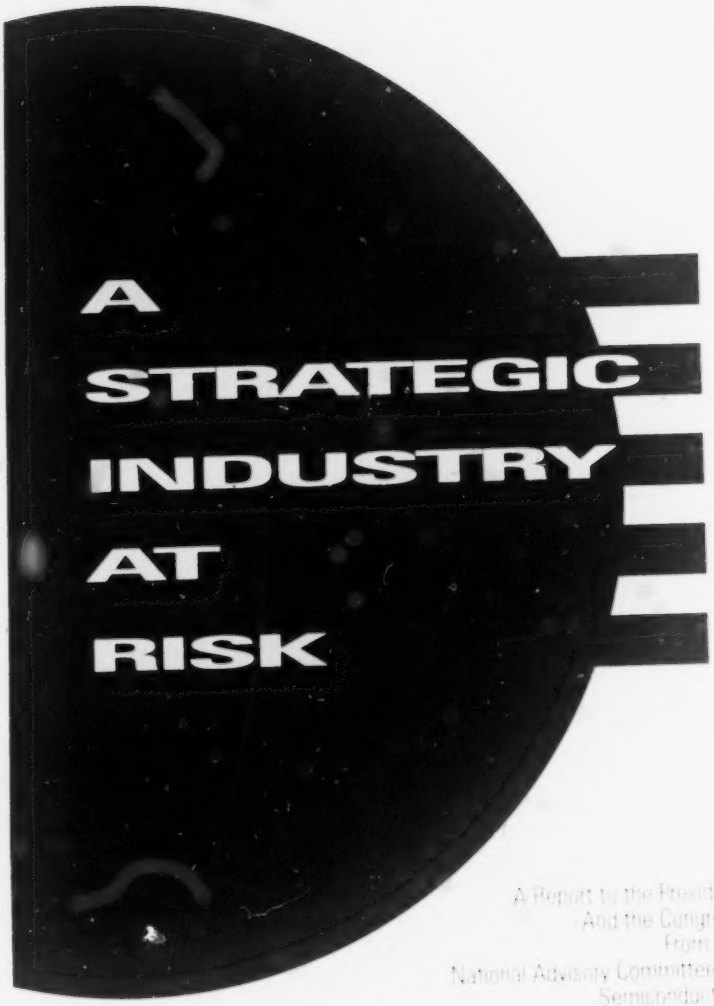
c. Ensuring that the DOE transfer synchrotron ring x-ray technology and systems for microlithography to U.S. industry and

aggressively pursue, with DOD's Defense Advanced Research Projects Agency, and the Department of Commerce programs in mask making, mask repair, aligners, metrology, and small x-ray sources.

CONCLUSION

This has not been an encouraging story. I would prefer to have given you a more optimistic viewpoint. Unfortunately, this would not have been honest on my part. I've personally witnessed the transformation of the world semiconductor industry from one in which America was the clear leader to one in which we are number two in market share. The gap continues to widen, giving rise to serious implications involving urgent issues in troubled times. These issues must be addressed with a national strategy involving both the public and private sectors. Concerted action over an extended time period by both industry and government will be needed to revitalize our domestic semiconductor industry and to reverse the trends I have described today.

SEMICONDUCTORS



A Report to the President
And the Congress
From the
National Advisory Committee on
Semiconductors

November 1989
Washington, D.C.

NATIONAL ADVISORY COMMITTEE ON SEMICONDUCTORS
1555 Wilson Boulevard, Suite 500
Arlington, Virginia 22209

November 1, 1989

Honorable George Bush
President of the United States
White House
Washington, D.C.

Dear Mr. President:

The semiconductor industry in the United States is in serious trouble. If this vital industry is allowed to wither away, the Nation will pay a price measured in millions of jobs across the entire electronics field, technological leadership in many allied industries such as telecommunications and computers, and the technical edge we depend on for national security.

The reasons why the once-dominant U.S. semiconductor industry is deteriorating are many. First and foremost is the fact that foreign producers enjoy advantages in ready access to low-cost patient capital for long-term investment. Foreign producers also operate in a business environment hospitable to cooperative ventures that are not general practice here, and they find shelter in home government protection against competition from abroad. But some blame for the semiconductor industry's poor health must also rest on the lack of long-range foresight of top management of American companies, who failed to realize the full consequences of retreating from key markets such as memories and consumer electronics.

The National Advisory Committee on Semiconductors believes that continued deterioration of America's semiconductor industry poses an unacceptable threat to U.S. economic and national security. We believe that this situation deserves your urgent attention. The Nation must act now, with the industry itself taking the lead and government at all levels participating as a strong partner. We believe that the American people, once fully apprised of the stakes involved for this country, will endorse the legislative and executive actions necessary to restore the semiconductor industry to good health.

The Committee recognizes that some of its recommendations may be controversial. We were charged by the Congress with "devising and promulgating a national semiconductor strategy." We have not shied away from controversy. In this report we present first steps toward a national semiconductor strategy. We believe that the country needs bold and innovative action.

This report warns of a major threat to the United States, a threat that endangers American industry, workers, and strategic self-sufficiency. That threat is immediate and serious and warrants the attention of the highest councils of government. In this first report, the National Advisory Committee on Semiconductors offers for your consideration and early action initial recommendations to counter that threat and enable the U.S. semiconductor industry to flourish. If this action succeeds, the whole Nation will benefit through more jobs, the creation of new wealth, and strengthened national defense.

Pursuant to Section 514?(c) of the National Advisory Committee on Semiconductor Research and Development Act of 1988 (Public Law 100-418), therefore, I have the privilege of transmitting to you the first annual report of the National Advisory Committee on Semiconductors.

Respectfully,

Ian M. Ross

Ian M. Ross
Chairman

CONTENTS

Preface vii

Executive Summary 1

The Semiconductor Industry and Its Vital National Role 5

The Decline of the Semiconductor Industry 9

Major Root Causes of the Semiconductor Industry Decline 17

Recommendations for Initial Steps Toward a National Semiconductor Strategy 23

Next Steps 33

Appendix 35

Bibliography 40

PREFACE

The 100th Congress established the National Advisory Committee on Semiconductors as part of the National Advisory Committee on Semiconductor Research and Development Act of 1988 (Public Law 100-418) to devise and promulgate a national semiconductor strategy. The Congress acted in response to growing public awareness of the importance of America's semiconductor industry to the national security and economic destiny, the increasing and pervasive loss of world market share in key elements of the industry, and the necessity of preserving this industry for the national good.

From the outset of its deliberations, the Committee agreed on the seriousness of the problems in the U.S. semiconductor industry. The Committee also recognized that this situation must be urgently addressed. This report represents early findings of the Committee, and is an effort to bring quickly to the President and the Congress suggestions for action.

In undertaking its work, the Committee drew on a number of federal studies of issues affecting the U.S. semiconductor industry and national competitiveness in general. In a number of areas, the Committee undertook additional studies to supplement the earlier work. Finally, the Committee called on the expertise of the American electronics community in the persons of Federal Government officials, industry executives, researchers, and private-sector economists and scholars. The Committee is grateful to these individuals for their help.

For development and analysis of the data and preparation of suggestions for recommendations, the Committee formed three Ad Hoc Working Groups -- Business Environment, Market, and Technology -- each headed by a Committee member and each drawing its membership from experts in the electronics field. The Working Group members provided the Committee with a broad and deep base of knowledge of the problems facing the American semiconductor industry.

The enabling legislation requires the Committee to report on its planned activities for the coming year. The Committee believes that this report contains early key recommendations for the President and the Congress, but also believes that continued development of recommendations is in order and that additional recommendations will be forthcoming in subsequent reports. The Committee expects to continue its work throughout fiscal years 1990 and 1991, releasing reports during this period as appropriate.

Current Committee members are listed in the appendix. In addition, the following Government members served as representatives under the past Administration: Dr. Ernest Ambler, Under Secretary of Commerce for Technology; Honorable Donna R. Fitzpatrick, Secretary of Energy; Dr. William R. Graham, Director, Office of Science and Technology Policy; and Dr. Alan Marty, Special Assistant to the Secretary of Defense. The Committee acknowledges their contributions to the report and thanks them for their service.

EXECUTIVE SUMMARY

The semiconductor industry is strategic to America. The industry is the foundation of the information age, playing a crucial role in the consumer electronics sector, the computer and telecommunications industry, and other industries that have a high electronic content in their products. America's national security also depends on the semiconductor industry. United States and North Atlantic Treaty Organization forces rely on the technological advantage of advanced semiconductors to offset the numerical superiority of potential adversaries.

The semiconductor industry, after an era of world leadership, is now in trouble. It has lost its dominant position in the world market. This radical change has occurred in the 1980s despite the fact that American industry invented, developed, and dominated the semiconductor market for three decades. Japanese companies, encouraged by their government, have taken aggressive actions to establish a world-class semiconductor industry that now clearly leads the world marketplace. The U.S. semiconductor industry has been unable, for many reasons, to respond to this challenge.

It is imperative that U.S. industry, in cooperation with government, develop a strategy to retain a strong semiconductor capability. Major U.S. electronics systems industries, such as computers and telecommunications, depend on the timely availability of leading-edge semiconductor devices. In order for U.S. semiconductor manufacturers to produce leading-edge components they, in turn, need timely access to the latest state-of-the-art semiconductor manufacturing equipment and materials. If the U.S. position in semiconductor devices, equipment, and materials continues to deteriorate, the entire domestic electronics products industry will be at the mercy of foreign suppliers. The loss of control of this large segment of the economy puts millions of jobs and billions of dollars of tax revenues in jeopardy.

A major result of losing semiconductor world market share is that U.S. semiconductor manufacturers are not able to fund research and development (R&D) at the level of their foreign competitors. Research and development spending at the top five Japanese semiconductor firms is now twice as high as spending at their U.S. counterparts. Unchallenged, this large difference will accelerate the U.S. loss of market share in the future.

There is no single reason for the decline of the U.S. semiconductor industry. The causes include changes in the business environment, shifts in the markets for electronic products, and weaknesses in the approaches used by the semiconductor industry to advance technology.

The business environment in the U.S. imposes fundamental disadvantages on American semiconductor manufacturers. These include a high cost of capital, weaknesses in the education of the work force, difficulties in enforcing U.S.

intellectual property rights abroad, and the ability of foreign competitors to benefit from closed markets and liberal antitrust laws.

One underrated but key factor in the deterioration of U.S. semiconductor leadership is the loss by U.S. producers of the consumer electronics industry. The shift to the Far East of manufacturing for nearly all consumer electronic products, such as televisions, video cassette recorders, and compact disc players, has had serious consequences because almost all the electronic components used in these products are also made in the Far East. In addition, because consumer electronics can drive technology applied to advanced commercial and military systems, for example in component packaging, foreign domination of the industry will put the United States at a greater disadvantage in the future.

As the U.S. position in the world semiconductor market has declined, so has its leading position in technology. For years the Japanese semiconductor industry has recognized the advantages of cooperation in the precompetitive phases of R&D. By contrast, the U.S. industry is characterized by relationships that are mostly competitive. Because U.S. firms have acted independently, each company is burdened with the full costs of advancing every aspect of new technologies. In an era of rapidly increasing costs of technology development, independent and duplicated efforts hinder competitiveness.

In the Committee's judgment, the United States is at a critical crossroad. The decline of the U.S. semiconductor industry, coupled with the increasing costs of staying at the leading-edge, limits the window of opportunity to establish an effective semiconductor strategy. Unless the U.S. industry and government take coordinated, concerted, and timely action, there will be a long-term deterioration of our industrial strength and military security, and an erosion of our economic wealth.

Recommendations: Toward a National Semiconductor Strategy

Timely industry action, supported by government, is required to arrest the deteriorating global position of the U.S. semiconductor industry. Industry and government must cooperate, with each providing its special strengths and acting in its appropriate role. The National Advisory Committee on Semiconductors has developed recommendations that serve as initial steps towards the development of a comprehensive national semiconductor strategy. These initial recommendations are:

1. Re-establish a fully competitive and supportive business environment in the United States to enable the U.S. semiconductor industry to operate on an equal footing with its major international competitors by:

- *Promoting capital formation.*
- *Improving the education system.*
- *Reforming trade law.*
- *Protecting intellectual property.*
- *Improving the antitrust climate.*

2. Expand the U.S. industry's global semiconductor market share by rebuilding a strong U.S. position in the growing high-volume, high-technology electronic systems market by:

- *Building a supportive business environment. There are several inseperable actions that must be implemented as a unit to accomplish this:*

Establishing a for-profit Consumer Electronics Capital Corporation (CECC) to resurrect the U.S. consumer electronics industry infrastructure by providing a multi-billion dollar pool of very patient, low-cost capital;

24-892 O - 90 - 2

Urging the President to direct the appropriate agency to determine those factors which reduce the likelihood of a successful U.S. consumer electronics industry. Redress shall then be immediately sought through cooperative agreements (with non-U.S. corporations), consumer electronics technology licensing, local technology content minimums, and local R&D and design (or any combination of the preceeding); and,

Having the Federal Government encourage and purposefully support market re-entry for the U.S. consumer electronics industry and improve its potential to compete vigorously. Accordingly, the Office of the U.S. Trade Representative shall ensure that access to the U.S. consumer electronics market shall be contingent upon reciprocal opportunity for U.S. companies to access foreign markets.

■ *Providing expanded market opportunities by encouraging private industry to accelerate the development of a nationwide broadband network providing fiber-optic cable to the home, by modifying regulatory policy where necessary and broadly experimenting with prototype trials.*

3. Enable the U.S. semiconductor industry to retain an enduring world-class, competitive technology position with a healthy semiconductor manufacturing equipment industry by:

■ *Accelerating research and development in the U.S. semiconductor materials and equipment industry by expanding the mission of SEMATECH, the semiconductor manufacturing technology consortium, in this area. SEMATECH's funding should be increased immediately by $100 million, half of which should be provided by the industry. In addition, a funding shortfall of $800 million exists over the next 3 years for programs fully to address the needs of this industry segment.*

■ *Sustaining the current Departments of Defense (DOD) and Energy (DOE) funding of $200 million per year that was previously allocated to very high-speed integrated circuits and direct it towards maintaining long-term industrial R&D efforts related to silicon technology and manufacturing tools.*

■ *Ensuring that the DOE transfer synchrotron ring x-ray technology and systems for microlithography to U.S. industry and aggressively pursue, with DOD's Defense Advanced Research Projects Agency and the Department of Commerce, programs in mask making, mask repair, aligners, metrology, and small x-ray sources.*

The Committee's full recommendations begin on page 23.

The Semiconductor Industry and Its Vital National Role

The uncommonly important semiconductor industry starts from some of the most common materials on Earth: sand, water, and aluminum. Through the application of complex manufacturing processes, these raw materials are transformed into the most intricate devices ever produced. Today, a single semiconductor integrated circuit chip can contain millions of microscopic components that channel the flow of electrons, and they can perform their tasks in a few billionths of a second. Before the next century, chips containing billions of components will be made.

The transformation of sand into complex silicon integrated circuits requires exceedingly high levels of scientific and engineering knowledge. The semiconductor industry's technological know-how encompasses a broad range of fields in the physical sciences such as physics, chemistry, electrical engineering, and materials science. The needs of the industry stimulate fundamental advances in these fields, and the resulting gains spill over to fill the Nation's reservoir of technological capability.

As chips become more complex, the costs of staying at the leading-edge escalate rapidly. Chip makers are at the forefront of all U.S. industries in their annual investment (as a percentage of total revenues) for research and development, and new plants and facilities. Since 1980, the cost of a typical state-of-the-art facility for semiconductor memory chips has risen eight-fold, from $25 million to $200 million. Over the next several product generations, state-of-the-art manufacturing facilities are expected to cost between $500 million and $750 million. Last year alone, the U.S. semiconductor industry spent about $3 billion on R&D and another $3.5 billion in capital investment. Such spending strains the resources of even very large companies.

Because more and more transistors can be packed on each chip, the cost per electronic function has fallen by a factor of 100 over the past 15 years. The gains in product performance have been commensurate with this extraordinary improvement in productivity. Compare, for example, the world's first electronic computer, America's ENIAC built in 1946, with an equivalent computer built today. ENIAC was room-sized, weighed 2 tons, drew power equivalent to 100 lighthouses, and used unreliable vacuum tube technology that frequently broke down. Today, American companies produce single semiconductor chips that have 1,000 times the processing power, almost never break down, draw no more energy than a night-light, weigh less than a gram, and cost 30,000 times less.

This tremendous improvement in productivity and performance has, in turn, opened semiconductor markets to ever wider applications. Semiconductor components are used ever more pervasively and intensively in almost all aspects of daily life. Today, chips drive products that help us to defend America, make medical diagnoses with sophisticated imaging equipment, navigate commercial aircraft, and warn when dangerous weather is approaching as well as improve the quality of our everyday lives through a broad range of consumer electronic products.

Today's $50-billion world chip industry leverages a $750-billion dollar global market in electronics products and 2.6 million jobs in the United States. This is more than double the number of jobs in the U.S. steel and auto industries combined. As products such as TVs, computers, anti-lock brakes, microwave ovens, and phone systems improve in performance and cost, demand for them increases. That increased demand prompts producers of these products to seek further advances from chip technology, pushing the industry forward toward further innovations. Such cycles of improved produc-

tivity and performance, and expanding demand for the products that take advantage of the improvements, create enormous economic and social gains. The benefits range from saving lives through improved medical safety systems to communicating by voice and data with any point in the world.

America's national security also depends on excellence in semiconductors. United States and North Atlantic Treaty Organization forces rely on a technological advantage ultimately traceable to semiconductors to offset the numerical superiority of our adversaries, as a Department of Defense task force affirmed in 1987:

"The superiority of U.S. defense systems of all types is directly dependent upon superior electronics, a force multiplier which not only enhances the performance of the weapons themselves, but also maximizes the efficiency of their application through sophisticated intelligence and command and control systems...The United States has historically been the technological leader in electronics. However, U.S. defense will soon depend on foreign sources for state-of-the-art technology in semiconductors. The Task Force views this as an unacceptable situation."[1]

Progress in the semiconductor industry advances the technical capabilities of industries that are linked to chips in the production chain, from computers and telecommunications to new materials, and indirectly advances many other industries. The semiconductor industry promotes the development of ever purer chemicals and materials, more powerful computer-aided engineering and design, and computer-integrated manufacturing, all of which find broad application in other industries. In addition, the products of the electronics industry are essential tools used to achieve the increased productivity, lower cost, and higher quality that are required

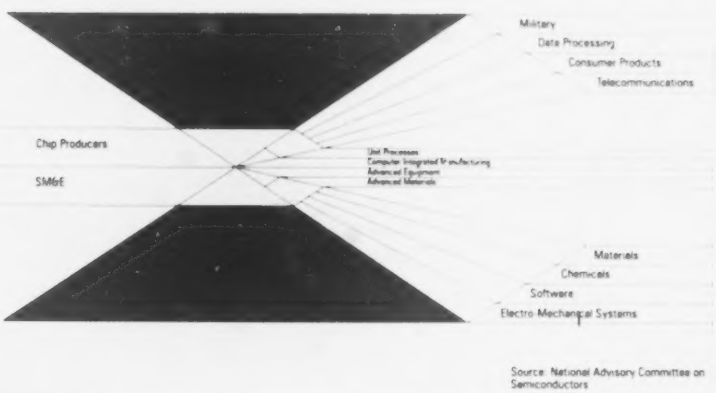


Figure 1: Semiconductors: The Enabling Industry

1 "Report of Defense Science Board Task Force on Defense Semiconductor Dependency," Feb. 1987, p. 1.

from all U.S. manufacturing. Leadership in chips can result in leadership in many industries -- a fact widely recognized by our major international competitors.

Because the semiconductor industry is so vital to the national economy, it is important to understand the structure of the industry and its position in world markets. The semiconductor industry has two major business segments. The first consists of the semiconductor manufacturers who actually produce semiconductor components (U.S. annual revenues are approximately $20 billion). These companies turn simple raw materials into finished wafers in expensive, ultra-clean manufacturing facilities. They also provide the packaging, testing, sales, marketing, and product support that are essential for success in the marketplace. The second segment of the industry includes the semiconductor materials and equipment (SM&E) firms that produce both the raw materials and the manufacturing equipment that go into the production of integrated circuits (U.S. annual revenues are about $5 billion). Together, semiconductor manufacturing and SM&E firms enable the entire U.S. electronics products industry, as illustrated by Figure 1.

The core of the electronic products industry is made up of SM&E companies. These firms supply the common set of tools and materials, used by most manufacturers, that enable efficient, low-cost, high-quality production. They supply both the equipment for various stages of the manufacturing process (photolithographs, materials processing, chip handling, packaging, and testing) and the ultra-pure silicon, gases, chemicals, and metals that are transformed into circuits. Loss of leadership in these technologies undermines more than just semiconductors. Indeed, the SM&E industry advances manufacturing disciplines as diverse as machine tools, vacuum control, automated controls, and computer-aided design. Advances within the SM&E industry, therefore, spill over into almost all aspects of the American manufacturing base.

Both the chip and SM&E industries have suffered declines in their world market positions over the past decade, as is demonstrated in the next section.

The Decline of the Semiconductor Industry

Evidence of the Decline in U.S. Semiconductor Manufacturing

The U.S. merchant semiconductor industry has lost its dominant world market share in the past 10 years[2]. Leadership of the industry has largely shifted to Japan, as shown in Figure 2. As a result, while United States semiconductor revenues nearly tripled from 1981 to 1988, revenues for Japanese producers rose six-fold. In addition to the loss of leading-edge semiconductor markets, the U.S. is continuing to lose market share in less complex discrete devices, as shown in Figure 3. These devices are key to a wide range of products from military equipment to consumer electronics.

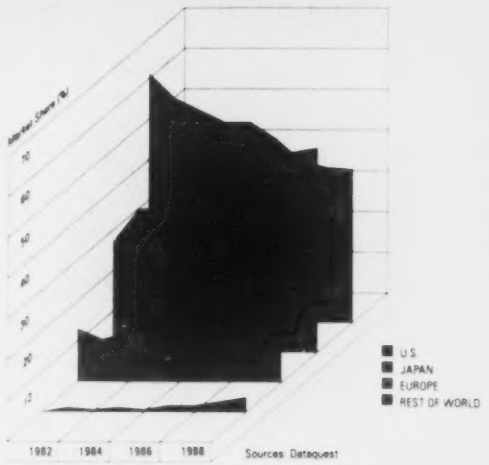


Figure 2: World Semiconductor Production by Region

Despite high investment rates relative to other U.S. industries, the U.S. chip industry is being substantially outspent by its major Japanese competitors in R&D and the gap is growing larger, as shown in Figure 4. In addition, Japanese firms have led U.S. firms in capital spending since 1982, although the United States had greater semiconductor sales until 1986. In 1988, Japanese capital spending was nearly $2 billion higher than that of the United States.

The erosion of the U.S. position is equally apparent in key semiconductor product markets. In 1970, when the first integrated circuit memory was being sold, Japan's market share was zero. In 1988, the world Dynamic Random Access Memory (DRAM) market share of Japanese producers was nearly 80 percent. This market share loss by U.S. merchant firms is shown in Figure 5. The loss of position in memory is particularly disturbing because leading-edge memory drives technological advances in a broad range of process and manufacturing areas.

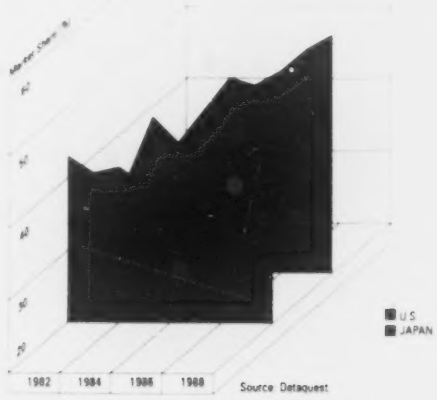


Figure 3: World Discrete Production by Region

[2] Since U.S. captive semiconductor manufacturers do not disclose their financial position, data are presented only for the U.S. merchant industry. Data for the Japanese semiconductor industry include all production. Inclusion of U.S. captive production would slightly increase the market shares shown for the U.S. in several figures, but would not change the trends described. Based on experience in the field, the Committee believes the conclusions of this report apply equally well to merchant and captive chip producers.

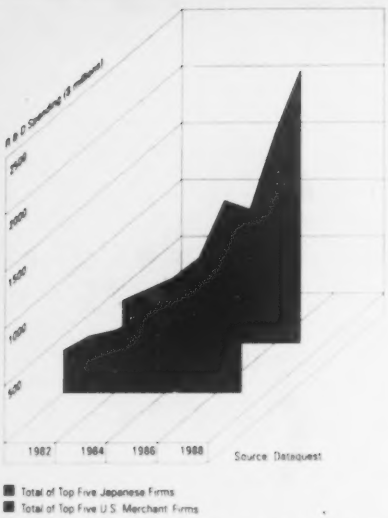


Figure 4: World Semiconductor R&D Spending

DRAMs not only act as a technology driver for chip makers, but they are also an important driver for SM&E firms, as new equipment and materials are often first developed for memory production.

The U.S. semiconductor industry's simultaneous loss of global technology and market position results in lower revenues, further reducing R&D and capital spending and leading to further decline in market share. It has already led to a change in the world leadership among semiconductor producers, as illustrated by Figure 6. This figure shows the change in the regional control of the market for metal-oxide-semiconductor (MOS) devices, which is the largest and fastest growing segment of the semiconductor market.

Reversing this trend will not be easy. Indeed, the cumulative loss of world market position by U.S. producers has had a serious effect on America's position relative to Japan's in many important aspects of semiconductor technology. The United States is holding its technological position in only a few areas, and gaining position nowhere. In critical technologies such as computer-integrated manufacturing, production quality control, and component packaging and testing, the United States has lost its technological superiority. Because technological knowledge is is cumulative, once technological leadership is lost, it is very difficult to regain. The United States, therefore, has an ever-shortening window of opportunity in which to regain technological leadership before it finds itself behind the state-of-the-art.

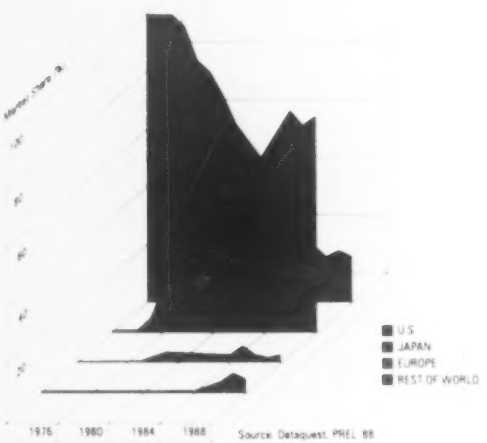


Figure 5: World Production of DRAMs by Region

Figure 6: Leading MOS Producers Revenues ($ millions)

Evidence of the Decline of the U.S. SM&E Industry

Paralleling the loss in world market share for U.S. chip manufacturing has been a serious loss of market share for U.S. SM&E firms. Because SM&E firms supply the common tools and materials used by all chip manufacturers, weakness in semiconductor equipment and materials leads to weakness in semiconductor component manufacturing, and ultimately to weakness in electronic products markets.

Today's state-of-the-art silicon processing, driven principally by the manufacturing requirements of semiconductor memory chips, is moving toward decreasing feature sizes. Eighty-five percent of all leading-edge submicron manufacturing capacity is currently in the Far East. The predominance of leading-edge chip manufacturing outside the United States has very seriously undermined segments of the U.S. SM&E industry largely because major foreign chip producers prefer working with local sources of supply they can control. These close working relationships spur equipment advances at foreign SM&E firms working with chip producers at the leading edge.

The U.S. SM&E producers of lithography equipment, test equipment, and materials have seen their commanding market shares reduced, as shown by the examples in Figure 7. The three equipment markets shown in this figure represent critical tools used in chip manufacturing, and are representative of the declining U.S. share of most equipment markets. In 1982, U.S. SM&E firms were dominant suppliers worldwide; today, Far East firms are dominant, as shown in Figure 8. The only major U.S.

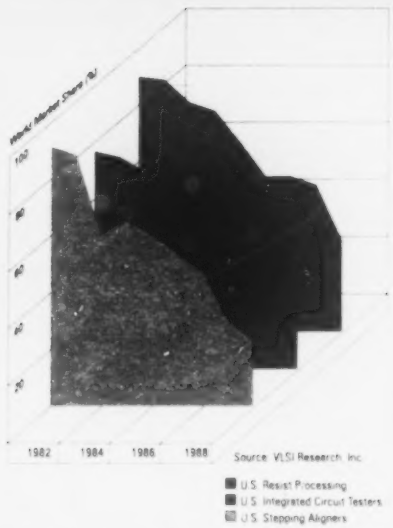


Figure 7: Selected U.S. Semiconductor Equipment

SM&E survivors have succeeded by establishing close customer relationships in Asia.

Maintaining a competitive position both in the United States and in the Far East is difficult for most U.S. SM&E producers, partly because their industry is highly fragmented and financially weak. While many Japanese SM&E firms are part of large, diversified companies, Figure 9 shows that 88 percent of the 850 U.S. SM&E companies had 1988 annual sales of less than $25 million. These companies face a difficult competitive environment of escalating capital requirements and R&D costs, while at the same time their major market is shifting to Asia.

Many U.S. SM&E firms still have excellent technology; the problem is that they will not be able to sustain their competitive position over time. They are also small enough to be attractive acquisitions for foreign conglomerates. Only recently, Materials Research Corporation (MRC), a critical U.S. manufacturer of semiconductor equipment and materials, accepted a tender offer from Sony. In addition, for several months Perkin Elmer has sought to sell its semiconductor lithography division. These companies represent important capabilities in the United States, and it would be damaging to the semiconductor industry, and to U.S. manufacturing as a whole, if these skills continue to migrate abroad. An example of the result of such a loss of U.S. capability is the sale of Monsanto's silicon materials business to the West German firm Huels, dropping U.S.-owned silicon wafer production from a 15 percent share of the world market to 1.8 percent. An initial analysis indicates that up to $1.2 billion over the next 3 years is required to restore this industry's health.[1]

Figure 8: Top 10 Semiconductor Equipment Suppliers' Worldwide Sales ($ millions)

[1]Analysis performed by the Semiconductor Equipment and Materials International (SEMI)

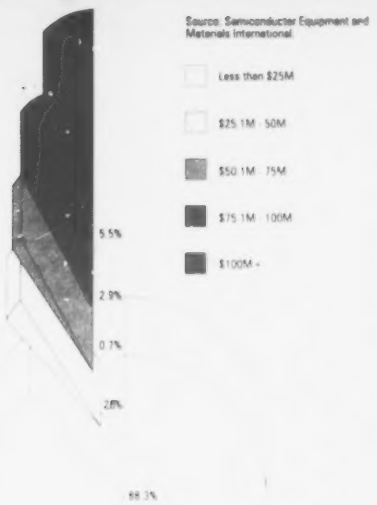


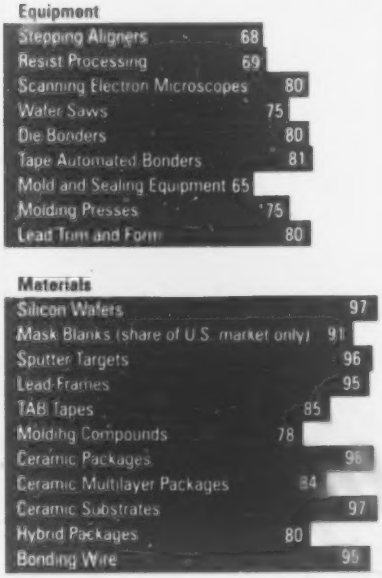
Figure 9: U.S. SM&E Industry Segmented by Annual Sales

The U.S. semiconductor manufacturing firms are already heavily dependent on foreign sources of critical materials and equipment, as shown in Figure 10. Even the largest and technologically strongest U.S. chip producers are at risk of failing to gain timely access to the SM&E technologies they need to remain competitive. Unfortunately, the prospect is for increased dependence and continued deterioration of the U.S. SM&E industry as long as its major customer, the U.S. chip industry, is itself in relative decline. The decline of the U.S. SM&E industry will likely be hastened by further inroads of Asian SM&E manufacturers; an industry survey indicates that 70 percent of the next generation of processing equipment purchased by U.S. companies will be produced in Japan.

The Committee believes that the continued decline of the U.S. semiconductor manufacturing and SM&E industries is unacceptable. Neither segment of the semiconductor industry can remain strong without the other. Manufacturers depend on early access to advanced materials and equipment, and SM&E firms rely on the revenues generated by sales to domestic chip manufacturers. America needs a domestic-based and controlled semiconductor industry with a full complement of leading-edge activities from

Figure 10: U.S. Dependence on Critical Foreign Semiconductor Equipment and Materials

Percent Imported 1988



Source: VLSI Research, Inc.

R&D through production, and with production costs, quality, and performance second to none. For the foreseeable future, neither imports nor foreign direct investment can ensure that the United States receives the same level of military, technological, and economic benefits that an American industry guarantees.

Consequences of the Decline

The economic, technological, and national security gains that flow from semiconductors provide a rare combination of benefits for America. The United States was able to capture those gains effectively so long as U.S. chip producers led the world and conducted nearly all of their leading-edge R&D and manufacturing activities at home. As the U.S. industry's competitive position and state-of-the-art domestic activities weaken, so does America's ability to reap the lion's share of the available national gains.

This point is most obvious from the perspective of national security. The qualitative edge in advanced weaponry that underlies America's strategic posture is put at risk by depending on trade flows that can be disrupted in wartime, and on foreign-owned capabilities, even if they are based in the United States.

Indeed, a recent publication[4] by Sony chairman Akio Morita and former Japanese minister Shintaro Ishihara highlights the growing issue of Japan's pivotal role in developing leading-edge military electronics technology that contributes to the U.S.-Soviet balance of power. They argue that because Japan has such dramatically advanced production skills, their semiconductors have achieved a level of sophistication unmatched anywhere. As a result, they contend the United States could become almost totally dependent on Japan to supply chips for its weapon systems. They go on to point out that if the supply of advanced Japanese chips to the United States were interrupted, and if Japan were to make these chips available to the Soviet Union instead, the balance of power would change dramatically.

The absence of a strong domestic U.S. semiconductor industry would also give leverage to foreign competitors to control the flow of economic gains from semiconductors to the rest of the U.S. economy. Indeed, a scenario believed possible by many observers in industry and government foresees the withering away of the U.S. semiconductor materials and equipment industry in the face of cyclical downturns in U.S. semiconductor production and increased Japanese competition. In this scenario, the fate of the U.S. semiconductor industry -- and, by extension, U.S. downstream industries -- would soon be in the hands of mostly Asian suppliers. In the scenario's denouement, Asia dominates the U.S. downstream electronics industry and ultimately the global electronics landscape.

Our major competitors have a demonstrated capability -- compelled either by policy or their own strategy and organization -- to act in concert and exercise market power sufficient to control access to technology and its price. Compelling examples include the DRAM shortage, the inability of U.S. supercomputer companies to purchase the fastest foreign chips, and the inability of most U.S. chip producers to gain timely access to the most advanced foreign semiconductor manufacturing equipment and materials. In all of these areas, U.S. industry has already lost control of its own destiny, and as a result U.S. economic strength and national security are at risk.

[4] *The Japan that Can Say "No"*, The New U.S.-Japan Relations Card, Akio Morita and Shintaro Ishihara

Exploitation and realization of the economic gains that flow from semiconductors depends upon the development of a cumulative, readily accessible, and leading-edge knowledge base. In the absence of a viable domestic industry, these factors would reside under foreign control. And they would reside there for a long period, because resurrecting a leading-edge U.S. industry, once lost, would take an extraordinary, concerted investment of time and resources. Neither imports nor foreign direct investment can relieve this dependency. Because nearly all of the R&D will be done outside the United States, imports can neither generate the kind of skill and knowledge base that a domestic-based industry generates, nor substitute for the cumulative learning that domestic activities provide. Nor, without taking substantial risks, can the Nation depend on foreign producers operating within the United States to carry on sufficient state-of-the-art science, engineering, and production and adequately to support the country's research base.

For all of these reasons, the Committee concludes that the United States can be certain of enjoying the economic, technological, and national security benefits that flow from semiconductors only if America's industry is at the leading edge, with a full complement of world-class activities from R&D through production here at home.

Major Root Causes of the Semiconductor Industry Decline

At the root of the U.S. semiconductor industry's loss of world position lie critical factors that have worked to the advantage of Far East producers. These factors include differences in the business environment that result in policies and practices, abroad and at home, that are detrimental to the U.S. industry. In addition, the markets available for U.S. semiconductors have shrunk as a result of shifts in the markets for electronic products. Finally, basic technological problems exist for the industry.

The Business Environment

One fundamental cause of decline in the semiconductor industry results from differences in policies and practices between the United States and its major international competitors, differences that lend advantage to foreign producers. The most critical differences are the access to low-cost capital, the ability and willingness of foreign producers to benefit from trade practices such as closed markets and dumping, the failure of U.S. schools adequately to train the work force, and the difficulty of enforcing U.S. legal rights abroad.

For U.S. chip makers, one of the most serious disadvantages is a lack of access to low-cost capital. This disadvantage is critical for U.S. chip firms because of the semiconductor industry's increasing capital intensity. While there is some debate over the precise values for the real cost of capital in the United States and Japan, there is agreement that costs in Japan have been significantly lower. This differential was particularly important during the early part of the 1980s when the Japanese semiconductor industry was investing heavily to expand capacity. A lower cost of capital enables foreign competitors to enjoy lower risk in making investment decisions, and consequently to operate with longer time horizons and greater immunity to swings in the business cycle.

Foreign competitors also benefit from supportive industrial policies and practices in their home markets. Policies range from closed domestic markets to subsidies and the coordination of pre-competitive research and development. Practices range from concerted pricing behavior to captive customer and distribution arrangements (e.g., through increased vertical integration and cross-ownership). Together, these factors have helped to create an unstable market environment with unpredictable financial returns for U.S. chip firms. This condition has discouraged the long-term investment perspective required for success in the semiconductor industry. The instability in the market was, for example, directly responsible for the dramatic decline in U.S. DRAM production.

These problems of the semiconductor industry are compounded by America's ineffective efforts to stay at the forefront of education and training. In a world where capital and technology move rapidly across national boundaries, a nation's competitive performance will depend on the continued quality of its work force. This fact is especially significant in advanced technology industries such as semiconductors. Successful firms blend theoretical physics and practical manufacturing skills. While our educational system has concentrated on educating talented students in theoretical disciplines, it has neglected training for manufacturing. In addition, manufacturing industries have been slow to communicate their needs to institutions of higher education. A revised education emphasis is required to support the gains in productivity and quality in manufacturing needed to keep the United States competitive. Companies that have recognized quality programs have found they have had to implement extensive corporate training programs for their employees at a cost that can, at times, rival their R&D budgets. Much of this training should have been a part of a fundamental educational curriculum.

The advantages of active quality programs are demonstrated by success in the marketplace. Asian companies were quick to recognize the importance of the customer's perception of quality in electronic products, as well as for semiconductor components. The U.S. firms that were late to understand that comprehensive quality programs are fundamental to manufacturing at the leading-edge have found themselves at a serious competitive disadvantage.

In addition, the Japanese have effectively used consensus and negotiation as a methodology for solving technical problems. This approach works well because of the relentless pace of technological change and the need for close cooperation between suppliers and customers in the semiconductor industry. In contrast, American industry has often been built on adversarial and contractual relationships. This approach slows reactions to emerging technologies, consumes valuable resources, and ultimately delays products introduction to the market. In a rapidly changing market, such delays can mean the difference between success and failure.

Finally, differences exist in the legal system and practices of chip-producing countries. In several key areas, notably intellectual property and antitrust, asymmetries between domestic and foreign laws frustrate the ability of U.S. companies to take full advantage of their competitive assets. Few countries in the Far East provide comprehensive protection of intellectual property, making it easier for foreign producers to reap the returns that would otherwise accrue to U.S. inventors. Similarly, foreign producers often engage in cooperative and coordinated behavior that would not be permitted under U.S. antitrust laws.

The Market

A fundamental problem facing U.S. chip makers is the migration of their customer base to the Far East. More and more of the world's electronics systems are being produced outside the United States, especially in Asia. In 1984, electronics systems produced in the United States and Europe consumed 63 percent of all semiconductors; by 1989, their combined share was only 47 percent, and Japan had supplanted the United States as the world's largest market. Even more important has been the shift in the production of consumer electronics products. At one time the United States held a dominant position in the production of products such as radios, televisions and video cassette recorders, but one by one U.S. market shares have been reduced dramatically. At the same time, the electronic content of these products has increased dramatically. As shown in Figure 11, consumer electronics products will consume more than $11 billion of semiconductors in 1989

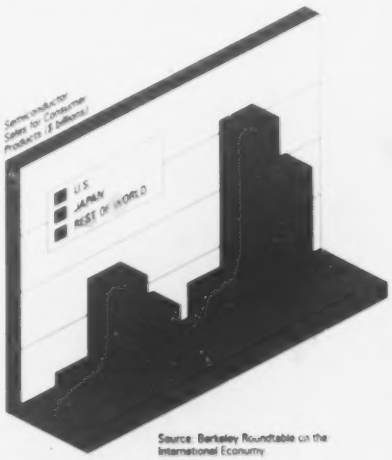


Figure 11: World Semiconductor Sales for Consumer Products Applications

-- more than 20 percent of the world's semiconductor production. Looking toward the year 2000, Japanese sales of semiconductors for consumer products are projected to be $13.5 billion greater than those of U.S. chip producers. If this projection is accurate, consumer products could fund more than $1 billion dollars of R&D in Japan in excess of that being funded in the United States. This difference in R&D funding attributable to the consumer products market alone is equivalent to the total R&D spending of the top five U.S. semiconductor firms in 1987.

Changes in the location of product manufacturing are important because the U.S. chip industry is more successful selling into the U.S. market than into foreign markets. Although losing market share, U.S. semiconductor manufacturers still control nearly 70 percent of the domestic chip market. In Japan, however, in spite of intense efforts by both U.S. manufacturers and governmental agencies, the United States has about a 10 percent market share, as shown in Figure 12, with no growth through the 1980s. Thus, as product manufacturing shifts to Asia, the total market available to U.S. chip producers is shrinking.

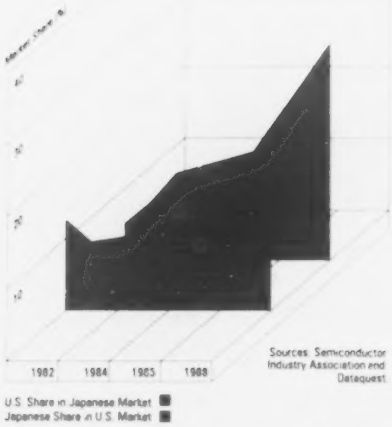


Figure 12: U.S. and Japanese Market Share in Each Other's Home Market

It should be noted that the Japanese share of the U.S. market has increased from 5 to 30 percent in the 1980s, as shown in Figure 12. There are two major reasons for the increasing use of Asian manufactured components in the U.S. market. First is the decline of U.S. market share in DRAMs. DRAMs now account for about 15 percent of the total semiconductor market, but the U.S. market share has dropped to less than 20 percent. Another reason for the decline in U.S. semiconductor market share at home is the use of foreign components in products assembled in this country by foreign firms. Although many Japanese companies assemble personal computers and consumer products in the United States, the designs are usually done in Japan and call for Japanese components. Although assembly jobs are created, the U.S. semiconductor industry is hurt by the reduction in sales volume and by a corresponding reduction in R&D funding.

Participation in consumer electronics markets will be even more critical in the future, as the newest consumer products increasingly use highly sophisticated chip technologies and are effective drivers of chip scale-of-integration, packaging, and sub-system assembly. Indeed, Far East producers are defining a new electronics market segment: high-volume, high-technology products such as camcorders and compact disc players, facsimile machines, laptop computers, optical disk mass storage systems, laser printers, and portable telephones.

Such products constitute the fastest growing world markets for chips. American electronics manufacturers currently participate only at the fringes of these critical new markets. Developing

a substantial new U.S. participation in these new consumer electronics markets would address a number of problems facing U.S. chip firms. First, increased U.S. presence in the manufacture of high-technology consumer products would provide additional markets for U.S. semiconductor manufacturers. Second, the same chips that would support a renewed U.S. consumer products industry could be marketed to foreign consumer products producers. Given the small market share currently held by U.S. firms, and the resistance to U.S.-sourced products outside of the domestic market, this effort may not produce substantial revenues initially. It would provide a better match, however, between the products U.S. semiconductor manufacturers sell and foreign markets demand.

Technology

For semiconductor firms to stay at the leading-edge of technology, the industry needs a long-term perspective, the patience to achieve high quality through steady incremental improvements, and an understanding that the technical knowledge required for success is cumulative over many product generations. Very large, precompetitive investments in people, technology, and facilities must be made years before products are ready for market. Precompetitive investments are not related to specific products, they are aimed at the development of the common tools and technologies that will be used later in a variety of applications. With each succeeding technology generation, the precompetitive costs are rising. Because major process generations must be started 5 years or more before products are brought to market, and major product generations are introduced every 3 years, it is necessary for semiconductor firms to bear the costs of more than one precompetitive effort at once. The process development costs for a single generation now reach $150 million, and are escalating rapidly. These costs strain the financial resources of even the largest firms in the industry. The Japanese semiconductor industry has recognized this for some time, and has engaged in cooperative precompetitive research.

In the past, U.S. semiconductor firms have not supported cooperative research in the early phases of process and materials development. They viewed their early research efforts as proprietary, and did not share the results with competitors or with equipment and material suppliers. This adversarial atmosphere created inefficiency, redundancy, and even the misapplication of equipment, and it limited the financial resources applied to any single effort to those that could be borne by a single firm. One opportunity for cooperative precompetitive research efforts is x-ray lithography technology development, which is critical to the production of future generations of advanced integrated circuits. This development is expected to be extremely expensive and could greatly benefit from the pooled resources of the semiconductor industry. The U.S. effort in x-rays lacks the breadth, cooperation, and organization of the program in the Far East.

The U.S. semiconductor industry has been late to recognize the advantage of such cooperative research efforts, and have only recently organized to pool their resources. One result is SEMATECH, a government-supported industry consortium dedicated to improving semiconductor manufacturing technology. By bringing together semiconductor manufacturers and SM&E firms prior to the competitive phase, it is hoped that some of the adversarial nature of their relationship can be avoided. A more cooperative atmosphere would reduce the costs for new equipment development at U.S. SM&E firms that have been hard pressed to fund enough R&D to remain competitive with foreign firms. A better working relationship would also

remove risk from new product development, because SM&E firms would have more insight into the emerging needs of semiconductor manufacturers. Although a necessary effort, the $200-million-per-year SEMATECH program is by no means sufficient to solve the semiconductor industry's problems.

Recommendations for Initial Steps Toward a National Semiconductor Strategy

Timely action by industry and government is urgently required to arrest the deteriorating global position of the U.S. semiconductor industry and restore that industry to competitive health. Industry and government must cooperate, with each providing its special strengths and acting in its appropriate role. Because of the immediacy of the threat and the extraordinary losses that will befall the Nation without prompt action, this first Committee report offers recommendations for immediate consideration and early action.

The following recommendations respond to the issues outlined in the last section. Taken together, they represent initial steps toward a national semiconductor strategy. They aim to:

- Expand the U.S. industry's global semiconductor market share.
- Establish a fully competitive and supportive business environment in the United States.
- Enable industry to achieve an enduring, world-class, competitive technology position with a healthy SM&E industry.

MARKET

Recommendation Number One:

REBUILDING THE U.S. CONSUMER ELECTRONIC INDUSTRY: An effective way to expand the U.S. semiconductor industry's market share would be to reverse the flow of the consumer electronics and equipment manufacturing (and company ownership) to Asia, while simultaneously increasing significantly the likelihood of success in rebuilding the U.S. consumer electronics industry. Accordingly, we recommend that the following inseparable actions be implemented as a unit:

■ ***ESTABLISH A CONSUMER ELECTRONICS CAPITAL CORPORATION (CECC):*** *The CECC should be a for-profit, privately managed investment holding corporation. Its mission should be to provide the momentum necessary to resurrect the U.S. consumer electronics industry infrastructure by creating a multi-billion dollar pool of low-cost, very patient capital. Its investments would be judged both on their long-term profit potential and their strategic value to the mission. The key objective should be the establishment of sustainable market share through the introduction of innovative, high-quality consumer electronics products. In light of the importance of establishing market share, profits should not be expected in the short term. The CECC would be responsible for financial and investment decisions and facilitating the development of independent operating companies; these companies would be run by proven business executives.*

Initial funding for CECC would be in the form of a multi-hundred-million-dollar equity investment from industry sources, private and institutional investors and State and local governments. Subsequent major funding should be forms of commercial debt, accompanied by pledges of support from federal, State, and local governments. The CECC would be subject to a specific debt-equity ratio in order to ensure that CECC bore some risk with respect to its debt. Multiple secondary offerings are anticipated to attract private equity investments directly in CECC's independent operating companies, gradually leading these companies to total financial self-sufficiency.

CECC would fund operating companies in the consumer electronics industry through equity investments. Emphasis should be on advanced technology development and productization.

CECC would work with State and local governments in conjunction with its operating companies with regard to the establishment, location, and support of manufacturing facilities.

CECC would search out consumer electronics-related technologies developed in United States laboratories, such as universities and the national laboratories.

CECC would function as a clearinghouse for consumer electronics R&D by working with U.S. electronics and components manufacturers to select key technologies and identify specific opportunities.

CECC would provide its operating companies with a range of support, the most important being financial and managerial.

■ ***PROVIDE AN EQUITABLE INDUSTRY OPERATING ENVIRONMENT:*** *The President should direct the appropriate Federal agency to: (1) determine, under applicable U.S. law, those factors that detract from the industrial operating environment and the expectation for successful investment by private U.S. investors in consumer electronics; and (2) seek redress of those factors. Such redress of these factors could include but not be limited to the following:*

Establishing cooperative agreements;

Initiating industry-led negotiations for the licensing of consumer electronics technology to U.S. companies;

Formulating and evaluating implementation policy options for local technology content; and

Conducting substantial local R&D and design work.

■ ***ENFORCE FAIR TRADE PRACTICES:*** *By means of the following, the Federal Government should encourage and purposefully support the entry and potential for U.S. industry to compete vigorously:*

The Office of the U.S.Trade Representative should ensure that access to the U.S. consumer electronics market be contingent upon reciprocal opportunity for U.S. companies to access foreign markets; and

The Department of Commerce should ensure and enforce timely application of anti-dumping laws with commensurate penalties.

Recommendation Number Two:

CHAMPIONING BY THE COMMERCE DEPARTMENT: The Department should be empowered to champion the establishment and maintenance of a benevolent operating environment for the U.S. consumer electronics industry and should coordinate the efforts of other cooperating Federal agencies. Additionally the Department should chair a working group of the Economic Policy Council concerning consumer electronics.

Recommendation Number Three:

ESTABLISHING STANDARDS: The Federal Government (including the Federal Communications Commission) should expedite the establishment of standards affecting the introduction of consumer electronics technologies and should cooperate therein with U.S. industry.

Recommendation Number Four:

ACCELERATING FIBER OPTIC SERVICE: By changing and harmonizing regulatory policy where necessary and broadly experimenting with prototype trials, the Nation should encourage private industry to accelerate the development of a nationwide broadband network providing fiber optic services to the home. Such a network would stimulate next-generation devel-

opment of a broad range of semiconductor-intensive consumer products (facsimile machines, digital photography, image compression, high-definition television, etc.) that would serve as a technology driver for high-volume, high-technology consumer product manufacturing. Priority should be given to U.S.-produced goods containing significant local technology content in prototype trials.

BUSINESS ENVIRONMENT

Recommendation Number One:-

CAPITAL FORMATION: The single most important consideration for the current and future health of the semiconductor industry is the availability, cost, and patience of capital. Therefore the following actions are recommended:

■ ***MAKING THE R&D TAX CREDIT PERMANENT (Channeling capital):*** *The U.S. R&D (technically research and engineering, or R&E) tax credit has been renewed for 1989, but remains temporary. Stimulation of corporate R&D, through improving and making permanent the R&E credit, is essential to U.S. competitiveness in high-technology industries. Legislation should be enacted to make the R&E credit a permanent part of the Tax Code, ensuring that a wide base of taxpayers is eligible for the credit, and allowing start-up ventures to claim the credit, even before market sales. The size of the credit should be increased, and it should be made applicable to all, not just incremental, R&D.*

■ ***REINSTATING THE INVESTMENT TAX CREDIT (Channeling capital):*** *The Tax Reform Act of 1986 eliminated the investment tax credit (ITC). Limitations on the use of the ITC carry forward amplified the negative impact of ITC elimination. The Congress should reinstate the ITC. Carry forward of the credit should be permitted. The market for U.S.-built over foreign-built equipment could be increased if tax credits favored U.S.-made equipment. The semiconductor equipment industry together with the semiconductor industry should propose ways to make the ITC favor the purchase of U.S.-made equipment.*

■ ***REDUCING TAXES ON CAPITAL GAINS (Supply and cost of capital):*** *The 1986 Tax Reform Act eliminated a long-standing policy of favoring capital gains with lower tax rates. The Committee supports proposals now before the Congress to reduce the taxation of capital gains. Special support is given to those aspects of the proposals that provide extra benefits for longer term investments.*

■ ***INCREASING PATIENT AND RISK-TOLERANT CAPITAL (Quality of capital):*** *There is widespread concern that American business management has an excessive preoccupation with immediate profit, sacrificing longer term, more risky opportunities that in other times may have been undertaken and formed the basis for major technological and economic breakthroughs. Financial regulators should review their regulations on investment advisers and pension funds and rules governing private placements and public issuance of new securities, to identify actions that discourage longer term investments and appropriate risk-taking, and to correct such biases.*

■ ***FACILITATING CONSORTIA (Channeling capital):*** *Industry and government have jointly funded SEMATECH. Other industry R&D consortia in semiconductors (such as the Semiconductor Research Corporation (SRC) and the Microelectronics and Computer Technology Corporation (MCTC)) have cleared antitrust and other restrictions. Some of these efforts do not, however, qualify for basic research tax credits. The Congress should enact and the Administration*

should support legislation to extend the definition of organizations qualified as eligible for the basic research credit to include a broad range of cooperative R&D efforts in semiconductors and other high-technology fields.

■ ***IMPROVING SM&E DEPRECIATION RULES (Channeling capital):*** *The Congress revised the depreciation schedule for semiconductor equipment in the 1986 Tax Reform Act to reduce it to 5 years from 8 years. At the same time, it mandated that the Treasury Department's Office of Depreciation Analysis review this matter and make a recommendation to the Congress by 1992. At this time, the Treasury Department has postponed an investigation on depreciation rates for semiconductor equipment until 1991. As groundwork for a proposed acceleration of depreciation schedules, the semiconductor industry should update the study of economic depreciation lives and include data on Japan, where there are much shorter depreciation schedules assigned for most advanced semiconductor equipment (1 to 3 years).*

■ ***EASING THE BURDEN OF SECTION 482 (Quality of capital):*** *Section 482 of the Tax Code requires that transfers of goods, services, and intangibles between U.S. companies and related parties outside the United States be priced as if they were market-based, arm's-length transactions between unaffiliated parties. A recent Treasury Department White Paper made comprehensive recommendations that included many modifications in current practices. These changes will result in greater paperwork, difficulties in interpretation, and greater uncertainty in intercompany relationships with especially onerous problems for semiconductor firms where risk and intangibles are shared among different corporate entities. The Treasury Department should revamp its entire approach to intercompany transfer pricing to incorporate less onerous documentation and record-keeping, greater accommodation of accepted, proven business practices, and greater certainty and less complexity in pricing transfers and allocating value.*

■ ***REDUCING THE FEDERAL DEFICIT (Supply and cost of capital):*** *The continuing deficits reduce our national savings and investment, contributing to our low rates of productivity growth. Although the shortfall of saving and investment may be offset to some degree by inflows of foreign capital, these inflows entail larger trade deficits and a reduced standard of living for Americans. The Congress should place a high priority on continuing to keep the growth of Federal spending below the growth of nominal gross national product. To the extent that changes in the Tax Code are considered necessary, they should be revenue-neutral adjustments used to tilt the tax structure away from consumption and toward increases in saving and investment.*

■ ***OPPOSING FOREIGN CAPITAL CONTROLS (Supply and cost of capital):*** *The net inflow of foreign capital into the United States has increased substantially over the past 6 years. There is growing dependence on foreign capital to make up for the shortfall of domestic savings. Disrupting these inflows could have potentially disastrous consequences for the United States. However, foreign purchases of U.S. corporate assets -- especially in strategically sensitive industries such as electronics -- are creating concerns that the United States is mortgaging its economic future. The recent increase of oversight authority to the interagency Committee on Foreign Investment in the United States (CFIUS) goes at least part way toward minimizing that concern. The CFIUS should comprehend the impact on entire industries, rather than case by case. The Committee opposes all forms of legislated restrictions on foreign capital flows, including reporting requirements for foreign investment.*

■ ***INCREASING PERSONAL SAVING INCENTIVES: (Supply and cost of capital):*** *Personal saving in the United States is lower than among its major competitors, including Japan.*

Using the income tax system to favor personal saving offers one means to increase personal saving. The Congress should broaden individual retirement account (IRA) provisions, including removal of restrictions on eligibility, increasing the allowed contributions, and expanding the uses of IRA savings-for higher education, for example. The taxation on interest from savings should be eliminated or reduced.

■ ***ELIMINATING DOUBLE TAXATION OF CORPORATE DIVIDENDS (Channeling capital):*** *In our income tax system, corporate dividends are taxed twice: as corporate profits and when received as dividends. This double taxation may discourage the use of equity financing and unduly encourage leveraging and earning retention. The Congress should integrate the corporate and individual income taxes to eliminate this bias. Any move toward integration that results in the loss of tax revenues should be accompanied by offsetting increases in consumption taxes or reductions in Federal spending so as not to increase the Federal deficit.*

■ ***OPPOSING LIMITS ON LEVERAGED BUYOUTS (Quality of capital):*** *Media coverage of large, leveraged buyouts (LBOs), in which new debt is issued to buy in equity in order to take corporations private, has brought calls for public policy to restrain such activity. Among the proposed "solutions" are limits on the tax deductibility of interest payments, as well as other legislative and regulatory restrictions. The Committee opposes ad hoc policies targeted at restricting LBOs and other forms of corporate restructuring.*

■ ***OPPOSING THE SPECULATION TAX (Quality of capital):*** *There is some support for a tax on short-term turnover of securities in financial markets. Advocates assert that such a tax would not only raise funds to cut the deficit, but would also discourage speculative turnover that can create instability and shorten managerial horizons. The Committee opposes such a tax on the grounds that it depresses stock prices and raises the cost of capital generally, and that the asserted benefits for capital market behavior are unproven. Any scheme to tax short-term investments should be considered only in the context of providing additional resources to further reduce taxes on long-term investment to rates below what they would be in the absence of the short-term tax.*

Recommendation Number Two:

EDUCATION: The semiconductor industry requires well-educated workers who can adapt to new technologies and who are flexible enough to respond quickly to an increasingly sophisticated workplace. Additionally, technical training, frequently at the advanced degree level, is the lifeblood of the rapid evolution of new generations of products and processes required for world-class competitive performance. Additional emphasis must be placed on training related to manufacturing engineering and on coursework supporting thrusts into advanced applications of total quality control.

■ ***PRESCHOOL:*** *Early childhood education offers the greatest potential for improving the quality of our educational system. A nationwide, quality, comprehensive preschool for economically disadvantaged, at risk, 4-year-old children should be implemented. For every dollar invested in quality preschool, $7 are returned to society during the lifetime of the child in the form of increased earnings, less crime, and less welfare.*

■ ***PRIMARY/SECONDARY EDUCATION:*** *To meet the needs for a literate work force, teacher competency should be enhanced and educational standards raised. A system of national teacher certification should be established that will supplement the States' minimum competency measurements. Business should share management skills with educators. Summer sessions taught by*

industry experts would help to develop mathematics and science teachers.

■ ***DROPOUTS:*** *The currently unemployed, uneducated, and unskilled must be provided the literacy and skills to qualify for current and future jobs in the workplace. Government should support literacy, mathematics, and science education under the Job Training Partnership Act. The country should develop an intensive, West German-type skills-training-employment alternative to high school.*

■ ***HIGHER EDUCATION:*** *The semiconductor, and other high-technology industries will require increasing numbers and quality of technical personnel to meet the standards established by international competition. Curricula stressing manufacturing engineering and total quality concepts should be emphasized. The Federal Government should increase immigrant permanent resident status visa quotas, and relax labor certification rules for non-U.S. Ph.D. graduates of U.S. universities.*

■ ***WORKPLACE LITERACY:*** *Most remedial programs are not available to people who are on the job, yet 20 million to 30 million adults have basic literacy problems. Alternatives should be explored to promote business and government involvement in improving workplace literacy. Federal and State tax credits for employee literacy training should be provided. A new title under the Job Training Partnership Act should be created to deal with adult work force needs.*

Recommendation Number Three:

TRADE LAW REFORM:

■ ***NEW INITIATIVES:*** *A senior U.S. Government interagency committee should consider, in the context of trade remedies or actions undertaken to counter unfair trade policies, whether additional governmental and/or private sector actions or policies are necessary to complement the current statutory processes as a means of promoting the competitiveness of the U.S. semiconductor industry.*

■ ***MARKET ACCESS:*** *Full access to foreign markets is critical. As the largest semiconductor market in the world, Japan must take immediate and meaningful steps to increase its purchases of U.S. semiconductor products. Specific sectors in Japan's market should be segregated for increased purchases, and the success of these efforts should be measured in terms of increased market share. The Administration should investigate the effectiveness of the sanctions currently in place to ensure compliance with Japan's commitments under the Semiconductor Agreement.*

■ ***EXPORT CONTROLS:*** *Export controls for both semiconductors and semiconductor manufacturing equipment should be adjusted to maximize export opportunities for U.S. producers to the highest degree possible consistent with security needs.*

■ ***ANTI-DUMPING LAW REFORM:*** *Anti-dumping law should be strengthened and made more effective by incorporating the principles being developed by the Semiconductor Industry Association and the American Electronics Association. Embodied principles should include accelerated processing of dumping cases, more effective penalties to deter dumping, and alternative approaches for the use of revenues collected from the dumping in third countries. The United States should actively support the strengthening of the General Agreement on Tariffs and Trade (GATT) anti-dumping code.*

Recommendation Number Four:

INTELLECTUAL PROPERTY:

■ ***SECTION 337:*** *The U.S. Government should maintain that the GATT panel report on Section 337 is legally faulty, and will not be accepted by the United States. The Administration should*

maintain continued support and appropriate enforcement in accordance with existing regulations and practices of Section 337, while seeking broadly supported alternatives to resolve any valid conflicts between Section 337 and GATT.

■ *GRANTING OF FOREIGN PATENTS: Government and private initiatives seeking more efficient patent-granting systems and harmonization of differences among national patent systems should receive increased emphasis.*

■ *NEW INITIATIVES: The Administration should convene a group to study and make recommendations within this Congressional term concerning clarification of mask works regulations regarding application-specific integrated circuits (ASICs) and new forms of protection such as design protection. National trade secret legislation should be reviewed in light of possible GATT and other international agreements to determine whether to urge accession by other countries to the Hague litigation conventions.*

■ *USE OF CURRENT MECHANISMS: The U.S. semiconductor industry should focus on protecting its intellectual property by availing itself of existing means.*

Recommendation Number Five:

ANTITRUST: Legislation to facilitate Production Joint Ventures, as the 1984 National Cooperative Research Act (NCRA) facilitated R&D joint ventures such as the Semiconductor Research Corporation and SEMATECH, would help to strengthen the U.S. presence in strategic infrastructure electronics industry sectors and thereby bolster American competitiveness. The Congress should amend the NCRA to expand the scope of the legislation to include Production Joint Ventures. Under the expanded NCRA, the "rule of reason" and not "per se" would apply to any court challenge to a Production Joint Venture. In addition, providing notice had been given, liability would be limited to actual, not treble, damages.

TECHNOLOGY

Recommendation Number One:

INCREASING R&D FOR EQUIPMENT AND MATERIALS: The U.S. semiconductor and SM&E industries must identify means to increase significantly the level of R&D activity dedicated to manufacturing tools, materials, and processes. SEMATECH's mission should be expanded to include project management for these development programs extending beyond 1993. SEMATECH's funding should be increased immediately by $100 million, half of which would be provided by the developers of such equipment materials and processes. In addition, a funding shortfall of $800 million exists over the next 3 years for programs to fully address the needs of this industry segment.

Recommendation Number Two:

CONTINUING FUNDING FOR SILICON R&D: The Departments of Defense (DOD) and Energy (DOE) should sustain the current $200 million per year funding previously allocated to very high-speed integrated circuits to maintain long-term industrial R&D efforts related to silicon technology and manufacturing tools.

Recommendation Number Three:

ENHANCING X-RAY LITHOGRAPHY: The synchrotron ring x-ray technology that has been developed in the national laboratories represents a unique capability and opportunity for future advancement of a critical semiconductor manufacturing technology. The DOE should ensure the transfer of synchrotron ring x-ray technology and systems for microlithography, by having two corporations design and build prototype rings and by funding the participation of national laboratory experts in these projects. In order to ensure timely availability and rapid insertion of this critical technology, DOD's Defense Advanced Research Projects Agency (DARPA), DOE, and the Department of Commerce programs in mask making, mask repair, aligners, metrology and small x-ray sources must be pursued aggressively as well.

Recommendation Number Four:

ENHANCING ACADEMIC RESEARCH AND TEACHING: The DOD, DOE, and the National Science Foundation should substantially enhance their funding of personnel, equipment, and especially facilities in support of academic research and teaching associated with silicon technology.

Recommendation Number Five:

ESTABLISHING METROLOGY AND STANDARDS: The National Institute for Standards and Technology should establish the sophisticated metrology and standards that industry will need for manufacturing technology in the coming generations of advanced semiconductors, including the x-ray era of microlithography. The new Technology Administration Act of 1989 is an appropriate step in that direction.

Recommendation Number Six:

ACCELERATING RESIDENCY: The Federal Government should evaluate and implement procedures allowing foreign-born students receiving M.S., Ph.D., and equivalent degrees in natural science and engineering from U.S. academic institutions to obtain permanent residency permits within 3 months after graduation, without departure from the United States.

Recommendation Number Seven:

DOUBLING SCHOLARSHIPS AND FELLOWSHIPS: *The Congress should double the number of federally funded undergraduate scholarships and graduate fellowships for natural science and engineering, and the real monetary value of these awards should be made more competitive with starting salaries in industry.*

Next Steps

The recommendations presented in this report represent the first critical steps towards a national semiconductor strategy. Further developing and working to implement that strategy is the goal of the next year of the Committee's activities. In fiscal year 1990, the Committee intends to:

■ *Promote Establishment of the Consumer Electronics Capital Corporation:*

Develop business plan;
Obtain seed capital;
Begin operation as implementation of the other unit actions permit; and
Achieve major equity infusion;

■ *Continue examination of issues pertaining to a national fiber optic network. Future efforts by the Committee will be directed towards further development of the business and government initiatives required to put this network in place;*

■ *Release a separate and more detailed report on the impact of the business environment recommendations on the semiconductor industry;*

■ *Continue analysis of what is further needed to revitalize the semiconductor manufacturing and equipment industry, and*

■ *Examine two new areas: the status of American industry involved in compound semiconductors (those made from materials other than silicon), and the implications for American industry of the development of photonics (integrated electrical and optical devices), which many observers expect to constitute the next major area of growth in electronics technology.*

APPENDIX

NATIONAL ADVISORY COMMITTEE ON SEMICONDUCTORS

Industry Members

Chairman:
Dr. Ian M. Ross
President
AT&T Bell Laboratories

Executive Director:
Dr. William R. Bandy
Program Manager
Defense Advanced Research Projects Agency
U.S. Department of Defense

Dr. John A. Armstrong
Vice President for Science and Technology
IBM Corporation

Norman R. Augustine
Chairman and CEO
Martin Marietta Corporation

Robert W. Galvin
Chairman of the Board
Motorola, Inc.

Jerry R. Junkins
Chairman, President and CEO
Texas Instruments, Inc.

James C. Morgan
Chairman and CEO
Applied Materials, Inc.

Charles E. Sporck
President and CEO
National Semiconductor Corporation

James G. Treybig
President and CEO
Tandem Computers, Inc.

Government Members

Honorable Robert B. Costello*
Under Secretary of Defense for Acquisition
U.S. Department of Defense

Honorable Erich Bloch
Director
National Science Foundation

Honorable D. Allan Bromley
Assistant to the President for Science and Technology Policy
Executive Office of the President

Dr. Robert O. Hunter, Jr.
Director
Office of Energy Research
U.S. Department of Energy

Honorable Thomas J. Murrin
Deputy Secretary
U.S. Department of Commerce

* Participated in beginning phase activities.

CONTRIBUTING STAFF

Coordinating Director	Michael B. Marks
Office of Science and Technology Policy Liaison	David Beecham
Office of Science and Technology Policy Administrative Support	Barbara Diering
Editor	Joseph Foote
Designer	Burchette & Company, Inc.
Research and Integration	Michael Borrus David A. Longfellow William W. Troutman
Economic Analysis	Robert B. Cohen
Legislative Analysis	W. Clark McFadden II

PROJECT MANAGEMENT STAFF

Program Manager	Sammy R. Smith
Deputy Program Manager	Hazel B. Houston
Analyst	Brian A. Morsch
Office Manager	Debra L. Brewer
Secretary	Peggy J. Minor

AD HOC MARKET WORKING GROUP

Chairman:
Charles E. Sporck
President and CEO
National Semiconductor Corporation

Norman R. Augustine
Chairman and CEO
Martin Marietta Corporation

Dr. William R. Bandy
Executive Director
National Advisory Committee on
Semiconductors

Michael Borrus
Berkeley Roundtable on the
International Economy
University of California

Dr. Robert B. Cohen
Visiting Scholar
Economic Policy Institute

Warren Davis
Vice President
Semiconductor Industry of America

Fred W. Horne
Vice President Corporate
Strategic Development
National Semiconductor Corporation

James McGroddy
Assistant General Manager
Technology Products
IBM Corporation

Michael B. Marks
Vice President Corporate Development
Science Applications
International Corporation

Timothy Richards
Director, Information Industry
Trade Policy
Office of U.S. Trade Representative

Larry Summey
President
Semiconductor Research Corporation

Jack Tramiel
Chairman of the Board
Atari Corporation

James G. Treybig
President and CEO
Tandem Computers, Inc.

Dr. Albert R. C. Westwood
Vice President Research and
Development
Martin Marietta Corporation

John Zysman
Berkeley Roundtable on the
International Economy
University of California

AD HOC ENVIRONMENT WORKING GROUP

Chairman:
Jerry R. Junkins, Chairman,
President and CEO
Texas Instruments, Inc.

Dr. David Beecham
Industry Relations Director
AT&T Microelectronics

Vladimiro Catto
Vice President Corporate Staff
Texas Instruments, Inc.

Robert W. Galvin
Chairman of the Board
Motorola, Inc.

James P. Gradoville
Manager International Trade Program
Motorola, Inc.

Emmett J. Murtha
Director of Licensing
IBM Corporation

James H. Peterman
Vice President, Semiconductor Group
Manager Industry Affairs
Texas Instruments, Inc.

Marshall C. Phelps, Jr.
Director Governmental Programs
IBM Corporation

Dr. Perry D. Quick
Quick, Finan, & Associates, Inc.

Robert A. Wagner
Vice President Corporate Staff
Manager Strategic Venture Projects
Texas Instruments, Inc.

AD HOC TECHNOLOGY WORKING GROUP

Chairman:
Dr. John A. Armstrong
Vice President for Science and Technology
IBM Corporation

Dr. Michael J. Attardo
Vice President and President, General
Technology Division
IBM Corporation

Dr. William R. Bandy
Executive Director
National Advisory Committee on
Semiconductors

Dr. Robert M. Burger
Vice President Research
Semiconductor Research Corporation

Irwin Carroll
Director, Joint Development Programs
Applied Materials, Inc.

Dr. James F. Decker
Director of Energy Research
U. S. Department of Energy

Dr. Frank L. Huband , Director
Division of Electrical, Communications
and Systems Engineering
National Science Foundation

Dr. Robert O. Hunter,
Director
Office of Energy Research
U.S. Department of Energy

Dr. James D. Meindl
Senior Vice President of Academic Affairs
and Provost
Rensselaer Polytechnic Institute

James C. Morgan
Chairman and CEO
Applied Materials, Inc.

Dr. David B. Nelson
Executive Director
Office of Energy Research
U. S. Department of Energy

BIBLIOGRAPHY

1. Jeanne Alford, *Meeting the Global Challenge: Advanced Electronics Technology and the American Semiconductor Industry*, Semiconductor Industry Association, Cupertino, California, 1989

2. Norman R. Augustine, Chair, *Report of the Defense Science Board Task Force on Defense Semiconductor Dependency*, Department of Defense, Washington, D.C., February, 1987

3. Michael G. Borrus, *Competing for Control: America's Stake in Microelectronics*, Ballinger Publishing Company, Cambridge, Massachusetts, 1988

4. W. Dale Compton and George E. Solomon, Cochairs, *The Technological Dimensions of International Competitiveness*, National Academy of Engineering, Washington, D.C., 1988

5. Robert B. Costello, Bolstering Defense Industrial Competitiveness, Report to the Secretary of Defense by the Under Secretary of Defense (Acquisition), Washington, D.C., July 1988

6. Robert B. Costello, *Enhancing Defense Standardization*, Report to the Secretary of Defense by the Under Secretary of Defense (Acquisition), Washington, D.C., November 1988

7. Edward E. David, Chair, *Report of the White House Science Council Panel on Semiconductors*, Office of Science and Technology Policy, Executive Office of the President, Washington, D.C., 1987

8. Charles H. Herz, Chair, *The Semiconductor Industry, Report of a Federal Interagency Staff Working Group*, National Science Foundation, Washington, D.C., 1987

9. William C. Hittinger, Chair, *Foreign Production of Electronics Components and Army System Vulnerabilities*, National Academy Press, Washington, D.C., 1986

10. David Packard, Chair, *A Quest for Excellence, Final Report to the President by the Blue Ribbon Commission on Defense Management*, Washington, D.C., June 1986

11. Clyde V. Prestowitz, *Trading Places*, Basic Books, Inc., New York, New York, 1988

12. David Russell, Chair, *High Definition Television (HDTV): Economic Analysis of Impact*, American Electronics Association, Washington, D.C., 1988

13. David H. Staelin, Chair, *The Decline of U.S. Consumer Electronics Manufacturing: History, Hypotheses, and Remedies*, Consumer Electronics Sector Working Group MIT Commission on Industrial Productivity, Massachusetts Institute of Technology, Boston, Massachusetts, 1988

14. Sidney Topal, *Consumer Electronics, HDTV, and the Competitiveness of the U.S. Economy*, Electronics Industry Association, Washington, D.C., 1989

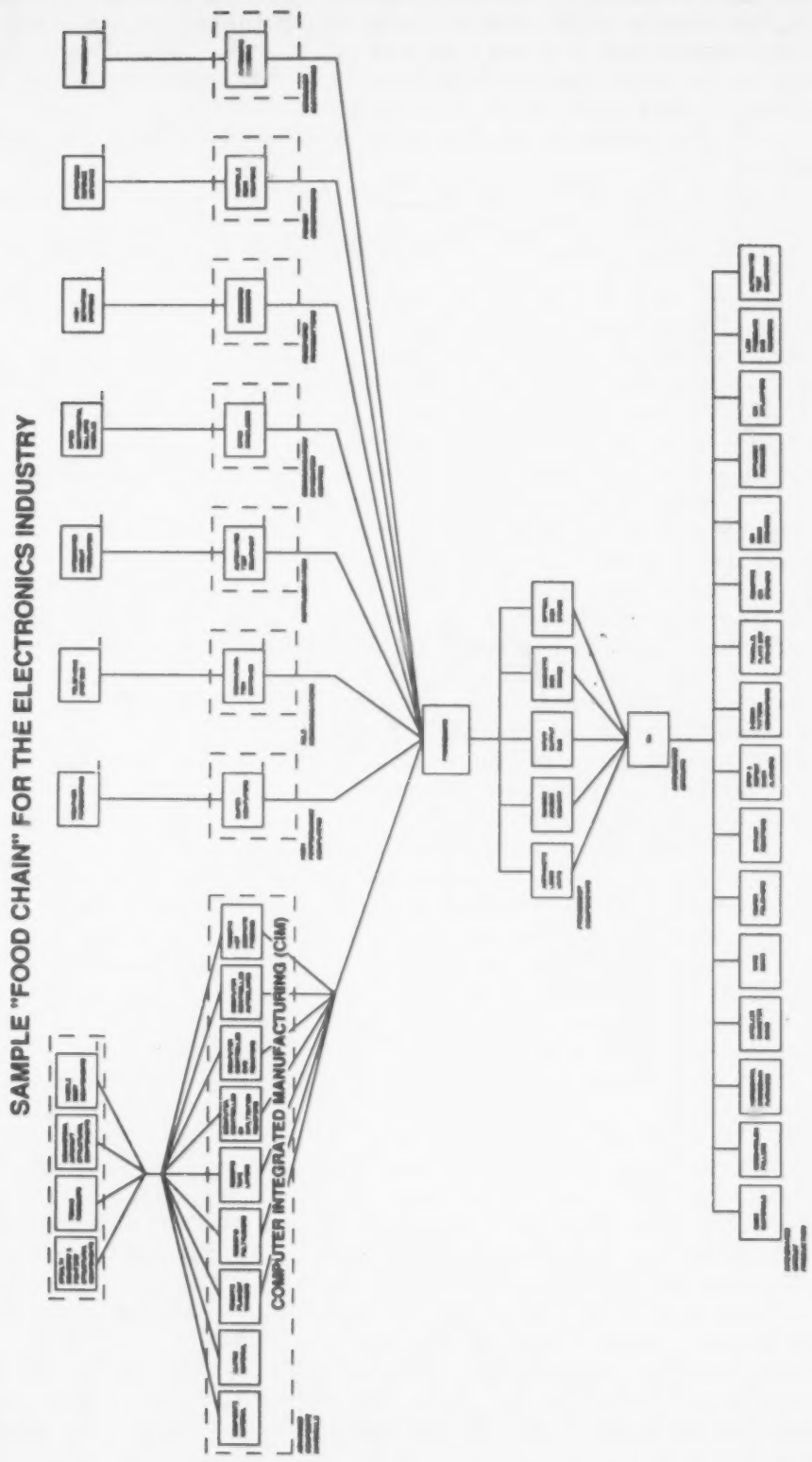
15. John A. Young, Chair, *Picking up the Pace: The Commercial Challenge to American Innovation*, Council on Competitiveness, Washington, D.C., September 1988

24-892 0 - 90 - 3

Senator BINGAMAN. Thank you very much.

Let me just start the questioning by asking if you would elaborate on the interconnectedness of these different levels of the electronics related industry.

You have this chart in your report that is, as I understand it, an effort to describe this so-called food chain or cluster of industries.


SAMPLE "FOOD CHAIN" FOR THE ELECTRONICS INDUSTRY
COMPUTER INTEGRATED MANUFACTURING (CIM)

Senator BINGAMAN. We have another one here which is totally illegible because of the size of it and the distance that we are from it (indicating), but it is one that was prepared for us by Project Socrates in the Department of Defense. It is a more elaborate version, I think, of your same chart, or it purports to be.

Could you elaborate on that a little bit and explain the importance of that?

Dr. Ross. Well, I, fortunately, have a copy of the illegible chart, which is a little easier to read.

Senator BINGAMAN. Yes. It is much easier to read in the small version.

Dr. Ross. But it is remarkably similar in its content and its appearance to the simpler one that we put together.

What we were trying to do was to illustrate the linkages, the interrelationships of these portions of the industry, and, in particular, that you do not have a healthy semiconductor industry unless it has a healthy market in electronics; and you don't have a healthy electronics industry without a good supply of leading edge semiconductor components.

The same kind of relationships exist between the U.S. manufacturing base, as we call it, in our chart, which includes the materials, the chemistry, the software, the electromechanical systems, and that manufacturing base depends for its health on having robust customers domestically in the semiconductor industry, and the semiconductor industry depends critically on having access to those leading edge materials, leading edge processes, at least in the same timeframe as our competitors overseas.

That was the point of our chart. We feel that it is very important that you do not look at any piece of this in isolation. All of these things are linked together.

Senator BINGAMAN. Dealing with one aspect of that, the semiconductor equipment field, we have had quite a bit of publicity just in the last week or so about Perkin Elmer and the threatened sale of Perkin Elmer's semiconductor equipment division to some Japanese firms. As I understand the reports, there is a lack of a U.S. purchaser for that technology.

Could you comment? Does your committee or do you individually have views as to the significance of that kind of loss?

Dr. Ross. Well, we did not, as a committee, look at P&E specifically.

We did look at the general trend in the industry, which is for U.S. companies to fold or to be sold overseas, and we consider that to be a very, very serious situation.

Now, the root cause of this is that these semiconductor manufacturing materials and equipment companies are finding it very difficult to make a profit in today's U.S. environment.

I think the disturbing thing is that it is not just the very small companies. Perkin Elmer is not a small company. This is a large company, which has a better chance to survive some of the ups and downs in the industry. Yet they, too, are finding that this is not a profitable business in which they can ask their shareholders to continue to invest.

I think it is a very, very serious illustration of what we were talking about in our report and what is happening throughout that part of the industry.

Senator BINGAMAN. The chart that you have, figure 8 on page 12, is where you list the semiconductor equipment suppliers and their worldwide sales.

Dr. Ross. Yes.

Senator BINGAMAN. When you go down that chart, it looks as though Perkin Elmer is a significant player, but has declined relative to quite a few others during the last 6 years, the period from 1982 to 1988.

The reports are that it would now be purchased by Nikon, which is the largest of the equipment suppliers worldwide.

Is that an accurate reading of things?

Dr. Ross. I think that is an accurate reading of things. I would add to that that Perkin Elmer has some very fine technology in the photo-lithographic part of the business. We were looking to that to assist with the semiconductor industry. If that becomes captive to Nikon, then it is another degradation in our capability.

Senator BINGAMAN. What realistically, though, can you expect or hope that Government would do to head off that sort of thing?

Are there U.S. firms that would step in and maintain that as a domestic capability if Government did a few things differently, or is this something which is not within our realm of realistic actions?

Dr. Ross. Well, Senator, I think this is a national issue that needs to be addressed by industry and by Government.

I think it may be a question of doing a number of things that would encourage corporations to stay in the business, rather than to get out of it.

Now, to the extent that the Government indicates that this is critical to the United States, indicates that things will be done to improve the environment in which they work, which includes what we are recommending on support of R&D, if they believe that the semiconductor industry chipmaking business is going to be revived in the Nation, I think all of these things would cause companies like P&E to decide to stay in, rather than get out.

But no one single thing, golden bullet or silver bullet, is going to solve this.

Senator BINGAMAN. Thank you.

I will have some more questions, but my time has expired.

Let me call on Senator Gore.

Senator GORE. Thank you very much, Mr. Chairman.

I have enjoyed the dialogue which has just taken place.

Let me continue that dialogue, Dr. Ross.

You have presented some fairly dramatic evidence to this subcommittee in what I would describe as "dry terms." This is appropriate, because you have been chartered to look at the facts and report back.

But let me ask you to put some gloss on those facts.

How far advanced is this process? Are we in the "end-game" now? Have the moves made by the Japanese already reached a point where the outcome of this competition is no longer reversible?

Can we, if we accept your recommendations, which, of course, are controversial. As you are well aware, the chances that all will be recommended are not good. But there is a chance that the country will become awakened to the seriousness of our plight here. And there is a chance that if that occurs, we will then adopt some reasonable semblance of the kind of strategy with the sense of urgency that you recommend.

If we do that, is it already beyond our capacity to reverse the process that is clearly underway in all of these graphs when they are read together?

Dr. Ros: Senator, I believe it is timely to attempt to reverse this.

The semiconductor industry is declining. At the same time, it is a strong industry.

We have not lost the technological capability in that industry. And, as I said in my testimony, it is the trends that are of much more concern than the absolute position that we see it in at the moment—not that we wouldn't like to see it with bigger market shares.

So, we see this as an industry that, if we move promptly, as a whole, we can turn around. We can stop this erosion and we can turn it around.

The place where the urgency is greater, for just the reason that you are implying, is in this semiconductor materials and equipment industry.

There I believe, and we believe, that if we do not do something soon to stop this bleeding in that part of the industry, we will get to a point where it may be irrecoverable.

Now, could I just comment on controversy and recommendations, my own point of view, and I think the committee will support me.

What we would most like to see is a serious debate, discussion, as to, first, do we have the problem we describe, and, if the Nation agrees that yes, there is a serious problem that needs to be addressed, then what are the options, including the options that we have suggested, that could deal with that.

But I think we would be most delighted to see that there be a healthy discussion of what our problems are and what the potential solutions to those problems are. And the advisory committee would be anxious to participate in that and to assist in exploring any solutions to this problem.

Senator GORE. Well, I think you are going to get that.

Senator Bingaman has taken steps to initiate this national debate, and this hearing is another in a series.

In the Senate Commerce Committee, on the Science and Technology Subcommittee, we have been looking at other related aspects of this same subject, one of which you alluded to in your statement.

You recommend a series of actions that would result in the construction of a fiber-optics network extensive enough to reach into every home in America. I have long advocated such a network, beginning some 10 years ago.

AT&T was not particularly enthusiastic about it at that time, I might say. Corning Glass, for some reason, was.

But, since then, AT&T has long since become supportive as well.

We are going to hear later from Dr. Allan Bromley, who has been quite supportive.

The administration has, after some study, formally endorsed the idea of this network. We passed legislation in the Commerce Committee requiring a lengthy study and a report addressing certain recommendations. That report has already been issued. You have expressed agreement with its overall thrust.

How would you rank that as a priority for America, a network of information superhighways?

Dr. Ross. Well, to the extent that it can support the infrastructure of the country in general and can stimulate the market for electronic products, both on the terminals and within the network itself, we think it is important that it be done in a timely way.

So we put a high priority on it.

Now, the deployment of such a network to the residents, to the customer premises, is not an easy task and will be paced by technology as well as by regulation and by national initiatives.

Senator GORE. Whether the telephone companies can provide cable television service?

Dr. Ross. Well, let me make a distinction. I believe today they can transport the signal. I think the debate is whether they can provide the programming.

Senator GORE. Whether they can make any money providing cable television service.

Dr. Ross. Well, you are taking me further than my expertise.

Senator GORE. We sometimes try to do that.

[General laughter.]

Dr. Ross. But the challenge here, and I think the very important phrase in our recommendation, is "to the home."

Senator GORE. Yes.

Dr. Ross. That has most of the difficulties in it, whether they be technical, political, or regulatory.

Now, one of the concerns we might have, though, is that if we were to deploy such a network, and it provides a market for Asian manufacturers and not for our own, that would be very unfortunate.

So I think it is important that our deployment of such a network be accompanied by a revival of the industry that will supply data and take data from that network.

Senator GORE. I agree.

Mr. Chairman, my time has expired, but let me go on for just a minute more if it is possible.

Senator BINGAMAN. Surely.

Senator GORE. You have presented us such a smorgasbord of subjects and ideas here. I am very impressed, let me say, with the work-product of your group and I want to compliment you on it. But in order to do justice with this particular subject, let me continue with it for just a second.

One of our strengths in world competition has always been the power and robustness of our consumer marketplace. We have in some instances been able to use the mass purchasing power of that market to our advantage.

We have not seen the use of America's purchasing power in this particular area. The manufacturers of supercomputers, for example, now routinely get much more interest from purchasers overseas than here in the United States. The kinds of businesses that

make these chips—Perkin Elmer has been discussed, and its competitors—are getting more interest overseas than they are here in the United States, from commercial purchasers here.

I think that one of the justifications for a fiber-optic network is that it accelerates and matures the ability of the United States to play an active role in the information marketplace.

There are, I would add, several other justifications—education, the ability of research teams in varying locations to work together through the use of such a network.

But this report offers yet another justification and argument in favor of moving forward with that fiber network, and I am encouraged by your recommendation.

Now, the semiconductor industry, through various reports and statements has indicated that Government help is going to also be required to survive—not just paying attention to the structure of the market, but Government help.

The AEA recently asked for over $1 billion in Government grants and guarantees for the HDTV industry. I personally believe that that is a key component of a successful strategy.

But many people are asking the question, "Why can't U.S. industry take the steps to solve their capital formation problem and not have to rely on Government for funding?" Is the industry doing what it can on its own without Government to help itself?

I know that fiscal policy, both in the legislative and executive branches, have handicapped any such response, particularly where the cost of capital is concerned.

But how would you answer those critics who say wait a minute, why don't we see the industry moving on its own to address the problem?

Dr. Ross. Well, Senator, if we look at what has happened over the last decade, I think we can all take some blame for the erosion of our consumer-electronics industry and our industrial strength in general. I think we can all take some blame for that.

And if you ask me again for root causes, I would say that it is a short-term mentality, a "now mentality," and that doesn't just sit in the board rooms. It sits in the residents and it probably sits in this building.

So I think we all have a piece of this.

I think that you can look at specific examples of where the industry in the past has acted unwisely. I think when the consumer-electronics business went overseas, that wasn't so much an environmental issue. I think it was to some extent the industry not recognizing what its competitive threats were from overseas.

The neglect of quality as being one of the most important customer needs of a manufactured product is another case where I think you can criticize U.S. industry, and I am delighted to say that is turning around and turning around very rapidly. And as far as quality, leading-edge manufacturing, we now have world-class manufacturing facilities in the United States and I think that is very encouraging.

Having said all of that, there is not much that an investor can do about a capital rate that is a factor of two higher than their competition's. I don't think we can blame the semiconductor industry in particular, which really has invested huge amounts in capital and

in R&D. We cannot blame them for having difficulty competing with folks who have half the capital costs.

So I think it is a question where we all have to do something better than we have been doing, and I believe that what we are asking for mainly is a sort of emergency treatment for the semiconductor materials and engineering (SM&E) industry and a better basic environment for the semiconductor industry itself.

Senator GORE. Well, I think you have made your case.

I am generally supportive of your recommendations and I appreciate your statement here today.

Thank you, Mr. Chairman.

Dr. Ross. Thank you, Senator.

Senator BINGAMAN. Dr. Ross, let me ask about your recommendations for the expanded mission of SEMATECH.

We have press reports indicating that the administration would like to cut back on support for SEMATECH. We have been supplying it Federal support at the level of $100 million. I gather that industry has done somewhat better than that.

Dr. Ross. Equal, I believe.

Senator BINGAMAN. Or equal, perhaps.

The recommendation in your report is that SEMATECH's mission should be expanded to include project management for these development programs, extending beyond 1993.

Let me ask, first, do you intend that SEMATECH would not just put more money into the same activity, but would, in fact, expand the area of responsibility that it has? If so, in what way.

Dr. Ross. My answer is yes.

SEMATECH has, I think, very properly focused its mission so that within the available funds, it has a good chance of succeeding. I think that the management of SEMATECH is to be greatly congratulated for doing that.

Senator BINGAMAN. So it has a reasonable chance of succeeding in the limited mission it now has?

Dr. Ross. That's correct.

We, in my company, as supporters of SEMATECH, are really very optimistic that SEMATECH is working and will continue to work.

Part of the reason it is working is that it has focused appropriately. So it has a good chance, as we said.

Now, what we are recommending is that—and, by the way, that focus—and I am sure you will ask Bob Noyce this—is on proving in the processes that are used by the chip manufacturers. That is a very, very good and useful focus.

What we are saying now is that we would like them to have the ability to extend that into overseeing more R&D in the SM&E industry.

They are doing some of that already, but we would like to see that more a focus, with more funding to do it.

Senator BINGAMAN. And your suggestion is that their Federal support be increased, or that their total funding be increased by $100 million this next year? You say additional funding of $800 million would be required over the next 3 years for these programs.

Do I assume that a third of that additional $800 million would be Government?

Is that it?

Dr. Ross. Our recommendation on the first $100 million was 50/50—50 percent Government, 50 percent industry—the way SEMATECH presently is funded.

Senator BINGAMAN. So it would go from $100 million of Federal support in this fiscal year to $150 million next year?

Dr. Ross. Well, I think we said immediately, whatever that is.

Senator BINGAMAN. Immediately.

If you can get it done in a year around here, that is "immediate."

Dr. Ross. That's why I qualified it. That is what we are recommending.

Senator BINGAMAN. Okay.

X-ray lithography is another area where you have a recommendation that the Department of Energy needs to ensure the transfer of synchrotron-ring X-ray technology and systems for micro-lithography by having two corporations design and build prototype rings and by funding the participation of national laboratory experts in these projects.

Could you elaborate somewhat on what is presently going forward in the area of X-ray lithography in the way of Government support and what you would recommend?

And why is it important? I think maybe that is the threshold question.

Dr. Ross. The key here is that the critical dimensions in the semiconductor industry are getting smaller and smaller. We are approaching the point where those critical dimensions will be smaller than the wavelength of light, in which case you cannot use light to expose the patterns on the silicone chips.

One way to go is to use X-rays. In order to do that, you need powerful sources of X-rays, and that is what these synchrotron rings are all about.

The national laboratories have, for other reasons, the need to generate such kinds of X-ray machinery. So what we are proposing here is the synergism, capitalizing on the synergism of things being done in the national laboratories with what needs to be done in industry.

So I look upon this as being an investment in next generation kind of technology, and it is more a question of providing a good, cooperative environment than it is of additional funding.

Senator BINGAMAN. Let me also ask about another of your recommendations which I thought was very interesting. You said the Federal Government should evaluate and implement procedures allowing foreign born students who receive an M.S., Ph.D. and equivalent degrees in natural sciences and engineering from U.S. academic institutions to obtain permanent residency permits within 3 months after graduation without departing from the United States.

Could you explain that and why that is crucial.

Dr. Ross. Well, it is important. At the moment there are regulations that require people to do strange things like going over the border to Canada and reentering in order to get the proper papers to become permanent residents. That seems like an unnecessary snake dance when we are dealing with valuable talent that has been trained in this country and could be used in the industry.

Senator BINGAMAN. So, you are really identifying here a problem with our immigration laws generally and saying that as to these particular foreign-born graduate students who have this training, it is particularly bothersome or a problem that should be addressed?

Dr. Ross. And I think that we are saying that we should encourage foreign talent, and I speak with great sincerity here, to remain within the country and to adhere to it.

Senator BINGAMAN. And you are living proof of that? [Laughter.]

I am sure we could go on with a great many other questions. Let me just ask about one other figure that you have in your report on page 13, figure 10, where you show dependency on critical foreign semiconductor equipment and materials.

Particularly in the area of materials but also in equipment it seems that our dependency is almost total. We are 97 percent dependent on foreign supplies for silicon wafers, 96 percent for sputter targets, and 96 percent for ceramic packages. What do you suggest that we do about this? This is not one of the things that is covered in your recommendation for a corporation to provide funding to the electronics industry.

Is there some specific recommendation that addresses this growing dependence on foreign supplies for the materials needed?

Dr. Ross. Yes. Let me make two comments.

Our recommendation to increase the funding and change the mission of SEMATECH is aimed at addressing that in part. We also, on page 28 in our next steps for the committee, say that we want to continue analysis of what is further needed to revitalize the semiconductor manufacturing and equipment industry. So here, Senator, is a case where in an interim report we have a suggestion, but it is not in our view a total solution to the problem.

Senator BINGAMAN. When do you expect to go forward and have a more final version of your report on this set of issues?

Dr. Ross. I do not have a milestone. Knowing that committee as I now do, I think we are capable of coming to some recommendations fairly promptly. I would hope we could do it within 6 months, and I would be very disappointed if we have not done it within a year, but I have not discussed that with the committee yet.

We have, frankly, been very much preoccupied with getting our present recommendations out to you.

Senator BINGAMAN. Let me just ask one question about your consumer electronics capital corporation, which I think is perhaps the most controversial of the particular items you have in here because it would involve a very substantial amount of additional money.

Now, I cannot tell from what I have read so far as to the extent of the Federal funding that you would anticipate being required for this kind of thing. You do indicate that most of the funding would be from commercial sources, I gather, and that there would be Federal Government loan guarantees to ensure low interest rates from the corporation.

Could you elaborate on the extent of the Federal dollars you think are needed?

Dr. Ross. Well, in principle we are saying zero, that the equity would be provided privately and that the loans would be provided from private funding.

However, we do need some form of Government support to permit the interest rates to be as low as possible.

Now, I do not know quite what form that would take. You said loan guarantees. We do not. We left it broader than that because clearly here is a mechanism that needs to be explored by more than just the committee as to what is acceptable and what is doable. So, we need support.

Now, it is unrealistic to say that that support comes at zero cost to the taxpayer. In some form or other it probably will. But until we have some feeling for what direction that might go in, we are not able to estimate what those dollars are. But, in principle we are talking about it all being private funded.

Senator BINGAMAN. Have you made a determination as to whether legislative changes, such as an enabling bill of some sort, would be required in order for this kind of capital corporation to be formed or could this be done without that?

Dr. Ross. Again, we have been at a little bit of a disadvantage—until we can socialize our recommendations, we cannot really explore them in depth where we need to explore them. But with that caveat, the look that we have taken at it says that it is likely we would need some form of legislation. But you cannot say that until we have really done further work, hopefully in cooperation with Congress on that.

Senator BINGAMAN. Okay. Dr. Ross, thank you very much. I am sure as we go forward we will think of additional questions and get back in touch with you on them. But thank you very much for your presentation and for the excellent work of your committee.

At this point let me go ahead with our second panel comprised of Dr. Allan Bromley, who is the Science Advisor to the President, and also Bob McCormack, who is the Acting Deputy Under Secretary for Acquisition with the Department of Defense.

Dr. Bromley, thank you very much for testifying today. Let me say that I appreciate the cooperative way in which you have taken your new job, and we have had opportunities to discuss various issues over the several months that you have been in this position.

I cannot recall the exact time that your position became formalized, but we very much appreciate your being in that position and know that you are making a significant contribution.

Why don't you go ahead with your testimony on the report of the National Advisory Committee on Semiconductors and anything else that you think we should be aware of.

STATEMENT OF DR. D. ALLAN BROMLEY, SCIENCE ADVISOR TO THE PRESIDENT AND DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, ACCOMPANIED BY DR. ROBERT L. POST, JR., ASSISTANT TO THE DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY

Dr. BROMLEY. Thank you very much, Mr. Chairman. I welcome this opportunity to come before you as Director of the Office of Science and Technology Policy to comment on this recent report of the National Committee on Semiconductors concerning the state of the semiconductor industry and to comment on the semiconductor-related technologies in general.

As you know, Mr. Chairman, I have submitted formal testimony, and I will not attempt to go through that in any detail, but will ask you if you will permit, to include it in the record.

Senator BINGAMAN. We will be glad to include your full statement in the record.

Dr. BROMLEY. I would also, Mr. Chairman, wish to emphasize at the outset that we are, as you know, in the final stages of pulling together the President's budget for fiscal year 1991, and for that reason I would find it impossible to comment on specific questions concerning that budget, and I know that you will understand.

The report that we have before us, "A Strategic Industry at Risk," provides, in my view, a very excellent in-depth analysis of the current state of the semiconductor industry. It was conducted over the past year with cooperation from officials from the Reagan administration primarily.

The report documents that our relative position in world semiconductor markets is continuing to erode rapidly although we still, Mr. Chairman, do retain world leadership in this industry. And, just as an indication of—to quantify it slightly—the best figures that I was able to obtain from the Department of Commerce for 1988 suggest that in high-technology electronics last year we exported products worth $200 billion.

The question that I think is before us here—and the question that the report raises—is really not necessarily what is going on in the semiconductor and other similar industries where there are similar problems but rather, I think, what we in the United States are going to do about it and how we will respond to these situations.

In my view, the current uncertainty, in terms of determining the most productive approach for us to take in the United States to strengthen the industrial technology sector, is rooted in what seems to be a rather hidden assumption that we really have to choose between massive Government subsidies of favored industries on the one hand or a total hands-off approach by the Federal Government on the other.

I would reject both of those approaches. I strongly believe that the real choices lie in a somewhat different direction. In the first place, I need hardly emphasize that the money for direct Government subsidies to somehow reverse the situations, in a brute force fashion, simply is not available. And, in fact, I remain convinced that even if it were available it is unlikely, in my view, that that is the approach that would work best.

On the other hand, nations such as Japan, I would point out, sir, are not experiencing these same problems. It is clear that there are striking differences. For example, the capital for the Japanese national investment is provided by savings from their private sector with a savings rate that approaches 14 percent, where ours is somewhat below 4 percent.

This tends to make much more patient, low-cost capital available, of course, in Japan. The most fundamental reasons for the success about which I have heard from experts in the field frequently are attributed to this long-term investment point of view so that immediate profits are not the goal of the investments.

Perhaps a more fundamental reason is the willingness of Japanese industries to work together in the pre-competitive phases of specific product development instead of each company, each industry, having to repeat the R&D—in effect to reinvent the wheel for each particular product area.

I would emphasize, sir, that the U.S. Government has played a strong role in helping industry in this Nation from its very inception. We all agree, for example, that the Federal Government has the duty to ensure fair trade treatment for U.S. industry in the global marketplace. Dumping and other unfair trading practices must not and will not be tolerated.

Our intellectual property rights must be protected, and are being protected. U.S. companies must have access to world markets free from tariff and non-tariff barriers. The administration has taken an active role in helping to ensure—insofar as we can—a level playing field in the global marketplace by reducing these barriers to fair and free trade.

The U.S. Trade Representative, for example, is presently addressing product dumping issues in the ongoing Uruguay Round of the General Agreement on Tariffs and Trade (GATT) talks. IPR issues are being addressed by the administration not only in that forum, but also in a number of our bilateral negotiations that are ongoing at the present time.

As the report before us notes, however, we have a large number of interconnected factors that are currently working against a competitive position in the semiconductor industry as well as in other high-technology industries.

The semiconductor industry is not unique in the difficulties that it faces. Among these difficulties are the following: U.S. antitrust legislation and, perhaps even more important than the legislation, the industrial perception of that legislation that still discourages collaborative approaches.

I think we have made substantial progress in addressing these problems, but certainly much more progress is needed.

Second, economies of scale will be essential if we are going to compete successfully. The capital investment, as Dr. Ross has indicated, required for modern chip manufacturing facilities is huge, and it is growing rapidly. Large sales volumes are essential.

If this equipment, this capital investment is to yield an adequate return, I think, too, that consortia between Government, academia and industry focusing on long-term technology goals will certainly enhance our ability to compete.

And finally a point that you emphasized earlier, sir, is that the entire future of the U.S. economy depends critically on how well our young people are educated and trained.

If we take these as some of the major problems that are highlighted in this report, then there are obvious suggestions for where we as a nation should go to respond to those problems.

In particular, I think that we should be encouraging horizontal as well as vertical collaborations. In my view an excellent and interesting example of that horizontal and vertical collaboration is in SEMATECH—the pre-competitive phase semiconductor industry consortium. In my view we need more such efforts in every high technology area of interest to the economic and national security of

the Nation. Collaboration from research and development through joint pre-competitive ventures between U.S. firms, which somewhat ironically already exists both in Japan and between U.S. and Japanese firms, could go a long way toward helping American industry to compete with their Japanese counterparts.

As was emphasized in the recent Education Summit, national performance goals for what students should be expected to know at each stage of their educational programs need to be established as also do mechanisms whereby performance can be measured against those goals so that we can produce a report card for all segments of our educational enterprise on an annual basis. This is a field to which this administration is very much committed.

One area that the Federal Government, in my view, should think very seriously about is that of generic, or perhaps, enabling, technologies. I strongly believe that in our modern technological civilization some technologies—and I would place the semiconductor technology group among them—occupy particularly strategic positions and exert a high leverage on many sectors of our economy.

These are the technologies that make it possible to do things that in their absence cannot be done as well, or indeed at all in field after field across the spectrum of our industrial, academic, and national security activities. The NACS report, I think, has made a very valuable contribution in focusing on one of those technologies.

To be successful, however, any of the various national advisory committees dealing with high technology industries must try to evolve policies and recommendations that are consistent with the current administration's economic policy concerns, and I believe that it is the role of the Federal officials of the Bush administration now named to the National Advisory Committee on Semiconductors and to similar advisory committees to try to ensure that such a close collaboration with the current administration policy does take place.

And finally, Mr. Chairman, I would simply emphasize that there are many recommendations in this report with which the administration finds itself in agreement and prepared, for example, to work enthusiastically to improve the macroeconomic climate.

I have mentioned a number of the other areas of agreement, but I should also mention to you that there are a few of the recommendations in this report that do not represent Bush administration policy.

These would include public support for a corporation to rebuild the consumer electronics industry, the question of defining minimum standards for local technology content, and allowing access to the consumer electronics market only for goods from countries that provide reciprocal access.

Again, let me say that I believe this report marks a very important contribution, as Dr. Ross has said, to opening up a critical dialogue in an area that is of very great importance to our future both within the civilian and in the national security sectors.

That, sir, completes my statement, and I would welcome the opportunity to respond to your questions.

[The prepared statement of Dr. Bromley follows:]

PROPOSED TESTIMONY OF DR. D. ALLAN BROMLEY
DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY
EXECUTIVE OFFICE OF THE PRESIDENT

Mr. Chairman:

Thank you for having me here today in my capacity as Director of the Office of Science and Technology Policy to comment on the recent report of the National Advisory Committee on Semiconductors (NACS) concerning the state of the semiconductor industry -- and to comment on semiconductor related technologies in general.

The report you have before you -- "A Strategic Industry at Risk" -- provides a thorough analysis of the current state of the semiconductor industry. It was conducted over the last year with the cooperation of federal officials of the Reagan Administration and shows that the U.S. is in danger of losing world leadership in the semiconductor industry. Even more disturbing are the trends it describes. In particular, it documents that our relative position in world semiconductor markets is continuing to erode rapidly. As the report notes, once a nation recedes from the leading edge of technology, it is extraordinarily difficult and expensive to regain that position.

In many ways, what has and is happening to the semiconductor industry is a paradigm for what could happen to other U.S. industries such as the computer and telecommunications industries unless corrective actions are taken in the immediate future.

Really, the question here is not what is occurring in the semiconductor and other industries; rather, it is, what are we in the U.S. going to do about it?

In my view, much of the current uncertainty with respect to the most productive approach to be taken by the U.S. for industrial technology lies in the hidden assumption by many that we must somehow choose between massive government subsidies of favored industries on the one hand, and a "hands-off approach" by the federal government on the other. I strongly believe the real choices lie in a different direction.

First, the money for direct government subsidies to somehow reverse the situation by brute force is not now available, and it is unlikely ever to be available. Even if such funding were available, it is unlikely that such an approach would work.

It is noteworthy that the Japanese have not achieved their economic and industrial success through massive government subsidies. Actually, the capital for their national investment comes from savings by the private sector. The most fundamental reasons for their success are a cultural bias toward the long term -- fostered by their low cost of capital -- rather than immediate profits, the presence of a collaborative approach between government and industry that makes good use of the strong points of each, and a willingness (often at the behest of the government) for industry to work together in the pre-competitive phase of specific product development.

In this nation, we, too, have always had a strong conception of a necessary government role in promoting

industrial vigor and growth. This dates from Alexander Hamilton's classic report on the domestic manufacturing industries, before the beginning of the nineteenth century. It is, of course, true that the U.S. government has a duty to insure fair trade treatment for U.S. industry in the global marketplace. Dumping and other unfair trading practices must not and will not be tolerated; our intellectual property rights must be protected; U.S. companies must have access to world markets free from tariff and non-tariff barriers.

This Administration is taking an active role in reducing barriers to fair and free trade. USTR is presently addressing product dumping issues in the on-going Uruguay round of GATT talks. The Department of Commerce and USTR are actively supporting U.S. industry in opening up the Japanese market to American-made semiconductors as called for in the 1986 Semiconductor Arrangement. IPR issues are being addressed by this Administration not only in GATT, but also in bilateral negotiations.

As the NACS report notes, we have a large number of interconnected factors that are currently working against a competitive position in the semiconductor industry, as well as in other high technology industries. I will mention just a few that seem particulary important to me:

- U.S. antitrust legislation, and U.S. industry perceptions of that legislation, are still discouraging the collaborative approach between businesses we will need in the twenty-first century. We have made substantial progress to address this problem, but more is needed.

- U.S. businesses in the semiconductor industry and others are fragmented and lack the economies of scale to successfully compete in the international arena over the long haul. For example, the capital investment required for modern chip manufacturing facilities is huge, and rapidly growing.

- A little more communication and consensus between government, academia and industry on long-term technology goals would enhance our ability to compete in the global market.

- The future U.S. economy depends critically on how well our young people are trained and educated. We should be giving our youth the tools they will need for success in life.

The framing of these challenges suggests where we, as a nation, need to go:

- While the U.S. government cannot and should not attempt to dictate the structure of U.S. industry, there is much that can be done in the future to encourage the economies of scale we will increasingly need to compete. In particular, we should be encouraging not only horizontal industrial collaboration, such as in consortia and the like, but also vertical collaboration as well. An interesting example combining both horizontal and vertical collaboration is SEMATECH, the pre-competitive phase semiconductor industry consortium. The horizontal collaboration is between

marketplace competitors such as Intel, National Semiconductor, AT&T and IBM. The vertical collaboration is between the equipment and materials vendors and their merchant and captive manufacturer customers. We need more such efforts in every high technology industry of interest to the economic security of this nation.

What is happening today is that the relatively small U.S. companies in the semiconductor industry and other high technology industries are competing with their Japanese counterparts that reside in large, vertically integrated corporations. It is an unequal competition. Collaboration, from R&D through joint pre-competitive ventures between U.S. firms, which ironically already exist both in Japan and between U.S. firms and Japanese, could go a long way toward meeting this need. Apart from re-examining our antitrust legislation, we need to better communicate with industry the real progress that has been made. So far, for example, the wide latitude given to pre-competitive cooperation by the National Cooperative R&D Act of 1984 has changed anti-trust attitudes somewhat; however, an "anti-trust mentality" in this nation, for understandable reasons, continues to exist. Such a broad, all-inclusive anti-trust policy is not now in our nation's best economic interest.

By every measure, we have been losing ground in the critical matter of our children's education. We need, as emphasized at the recent Education Summit, national performance goals for what students should be expected to know at different stages of their educational program and mechanisms whereby performance can be measured against such goals. In this way, students, teachers, schools, states and the federal government can be provided with annual "report cards" so that we can monitor performance objectively as well as identify problem areas early enough to permit effective remedial action.

Finally, I would like to comment on the notion of critical technologies. I strongly believe that in our modern technological civilization some technologies occupy particularly strategic positions and exert high leverage on many sectors of our economy. They are the technologies that make it possible to do things that cannot be done as well or, indeed, at all in their absence in field after field across the spectrum of our industrial, academic and national security activities. I believe that there is a general consensus that semiconductor technologies fall in this class.

The NACS report has made a valuable contribution in focusing on one of these technologies. This report before you is one that merits serious consideration; it represents the first phase of a study that will be continuing over at least the next several years. To be successful, this Committee's work must be consistent with current Administration economic policy concerns. It is the role of the federal officials of the Bush Administration now named to this Panel to ensure that such a close collaboration with current government policy does take place.

I would be happy to answer any questions concerning the recommendations in the NACS report, or on any related topics. I do, however, wish to emphasize that many of these recommendations, especially with regard to government intervention in the semiconductor industry, do not represent Bush Administration policy. In particular, a number of the recommendations in the report are controversial, including:

-- public support for a corporation to rebuild a consumer electronics industry in the U.S.;

-- defining minimum standards for local technology content;

-- allowing access to the U.S. consumer electronics market only for goods from countries that provide reciprocal access; and

-- major increases in federal funding levels for SEMATECH.

These and similar recommendations in this report have been criticized as implying a kind of interventionist "industrial policy" that this Administration strongly opposes.

This completes my testimony. I would be glad to discuss with you any other related matters.

Senator BINGAMAN. Thank you very much. Let me ask, first, about a specific case—and that is Perkin Elmer, the case that I asked Dr. Ross about.

Do you have a view as to whether Government should step in and try to ensure that Perkin Elmer, a company with a major position as a semiconductor equipment manufacturer in this country, be kept as a domestic firm?

Is there a position on that, or if not, what could you tell us about your views?

Dr. BROMLEY. There is no formal position yet, sir, but let me tell you my views at this point. I recognize that Perkin Elmer is the last major supplier of the critical instrumentation that underlies the production of semiconductors in this country, and for that reason it seems to me that it is of particular importance to the future of that entire industry, as Dr. Ross has already stated.

One of the hopes that I have had—and I have known about the Perkin Elmer situation for some time—I have known that its instrumentation division was available for sale for a long time, and I had hoped that its customers here in the United States who rely on Perkin Elmer and similar corporations for their production instrumentation would examine possible, if necessary novel and innovative ways, to retain Perkin Elmer in business.

I had hoped, for example, that it might be possible for them to consider setting up their own consortium to buy that Perkin Elmer Division, particularly if they agree that foreign ownership of the division would hurt their competitive position.

With respect to the other aspect, the national security aspect of such a sale, there is in fact a formal mechanism already in place as you know, sir, put in place as an amendment to the Trade Act last year, and that is the Committee for Foreign Investment in the United States (CFIUS), which operates out of the Treasury Department.

That committee will automatically look into any proposed sale of Perkin Elmer to a foreign buyer and will examine whether that sale impacts in any negative sense on the national security interests of the United States. If in fact it finds that to be the case, it has the power—given to it by you in the Congress—to block that sale.

CFIUS has already examined some 160 cases, so it has a track record of looking into these matters and I fully anticipate that were this sale to proceed—and there is no paperwork to my knowledge yet, relating to the sale of Perkin Elmer—but as soon as some would become available, even in a preliminary fashion, then the Committee for Foreign Investment would become involved.

Senator BINGAMAN. Thank you very much. Let me say that on the 3rd of November I wrote a letter, with Senator Exon, to Secretary of the Treasury Brady, who chairs the Committee on Foreign Investment in the United States, urging that he look into this very deeply and try to make an assessment as to whether there was a real national security problem involved in losing this capability and allowing Perkin Elmer to become acquired by a foreign company.

We do not have any response. I would not expect one at this time. I have also sent letters to Secretary Mosbacher and to Secre-

tary Cheney, since they are also involved. I have to tell you I am a little skeptical about that group's success.

You indicate they have looked into 160 cases. My information is this committee has yet to find one that they believe does pose any kind of national security threat to us, so we are batting zero for 160 times at bat. I hope that we do better in the case of Perkin Elmer.

On SEMATECH, you indicated your support for SEMATECH and that type of venture. One of the recommendations of the Advisory Committee is that the mission of SEMATECH be broadened and that the funding for SEMATECH be increased so that they can pursue a broader set of missions. I would be anxious to get your views as to whether that course is appropriate.

Dr. BROMLEY. Let me again, if I may Mr. Chairman, note that we are in the final stages of a budget review in which this matter is obviously under consideration and therefore I cannot comment in detail.

But let me say that I personally, first of all, am completely unaware of any move to reduce the support for SEMATECH. I personally favor this kind of collaborative industrial precompetitive program and while I believe that increased Federal spending, per se, is not the answer for U.S. competitiveness alone, it is certainly clear to me that on a case-by-case basis there will be situations where the infusion of Federal dollars will play a very important and catalytic role. I certainly do not exclude that.

A particular example, in my view, of Federal expenditures that represent a superb investment is the support over the years that you and your colleagues have provided to the research enterprise nationwide.

I would also point out, too, Mr. Chairman, that in the last year for which I have numbers—that is 1986—the Federal Government here in the U.S. funded semiconductor research and development at a level of over $500 million annually, while the Japanese Government invested only $56 million. Now obviously, what that means is that Japanese industry was much more involved in supporting the enterprise than was the case here.

The fact is that we do spend a great deal of money on basic research; we are still funding the semiconductor area, as these numbers would indicate, at something like an order of magnitude higher than is the case in Japan. I would conclude from those numbers simply that money alone is not going to solve the problems that we see at the moment.

Senator BINGAMAN. Let me ask about one other thing. There are several people who have been pursuing the theme that even those who oppose an industrial policy for our country should still acknowledge and support a technology policy. Such a policy would keep us at the forefront of technological development so that that technology is available for use by our industry and our industry is not at a disadvantage relative to other countries in that respect.

Do you have any views as to the appropriateness of that kind of a thrust, or approach, to some of these funding issues?

Dr. BROMLEY. Yes, Mr. Chairman. I find myself in agreement with your point of view. I believe that there is indeed a very impor-

tant role for a technology policy and I believe that the administration supports that view.

What the administration does not support is the industrial policy concept, and perhaps I should explain what I understand, at least, to be the distinction between those two.

In the current technology policy, and in the kind of technology policy that my office is committed to drafting for you and your colleagues sometime early in this coming year, the Federal agencies select for funding, areas of R&D, scientific disciplines and applications that are appropriate to the agency missions.

R&D support for these particular industries depends on the actual missions of those agencies, and examples are in agriculture and mining, aeronautics, health standards, instrumentation and so on, and it seems to me that the Federal Government really should fund application development and demonstration in areas such as defense where it is the primary customer.

There is also an appropriate role for Federal Government funding in areas where the private sector, for whatever reason, cannot invest sufficient amounts, such as in long-term research or in areas where the results are necessary for a large number of disciplines and are only perhaps peripheral to many of them.

I would call these "generic," or "enabling" technologies, and I think that we in the Federal Government have a very real role in catalyzing and supporting the development of those technologies, because they undergird a tremendous amount of the technological superstructure on which we depend both in the civilian sector and for national security.

On the other hand, I think of industrial policy in terms of cases where the Government picks out particular industries, or firms, to receive preferential treatment. In general, firms in such areas are produced-oriented and the usual argument is that Federal intervention is required to keep those organizations in a competitive stance.

Such a process tends frequently to be a political, nonanalytic process for determining winners and losers—who gets the preferential treatment and who does not. I also see that process as being a rather risky, short-term fix for a specific problem and not, in general, as a successful strategy for long-term competitiveness.

Senator BINGAMAN. Thank you very much. My time has expired. Senator Gore.

Senator GORE. Thank you very much, Mr. Chairman. Welcome, Dr. Bromley.

Dr. BROMLEY. Thank you, Senator.

Senator GORE. I have enjoyed our dialogue since your arrival in Government.

I will say to Senator Bingaman that on the Commerce Committee I have the pleasure of chairing the Science and Technology Subcommittee which had the hearings on Dr. Bromley's confirmation, and we found his breadth of knowledge to be most impressive, and as I say I have enjoyed our conversations even though sometimes we have disagreed.

I enjoy watching your mind work and listening to your conclusions. On this subject, Dr. Bromley, you are sounding sympathetic to the viewpoint expressed by Senator Bingaman, myself and others, and on some of these subjects I think Senator Lott, but I

sense a reluctance on your part to really commit to any proactive role to help solve the problem.

Perhaps that is an unfair conclusion, but you say there is an argument for help on a case-by-case basis. Is the semiconductor industry one of those cases?

Dr. BROMLEY. I would believe so, sir. I see a spectrum of technologies and situations. On the one hand we have the research, the basic research area, then the precompetitive development of technologies, and on the other hand we have the immediate product development, product production and optimization.

I strongly support Federal support of the end of that spectrum toward research and development of the underlying noncompetitive technologies, and I believe that that represents the administration's position.

But when you get to the other end of the spectrum, where you approach production and when you actually become involved in production, then that becomes much closer to what I have just defined as industrial policy.

Senator GORE. So in your view the proper role for Government is really to support the basic research, but the closer you get to the market the less of a role Government should play, right?

Dr. BROMLEY. I would only modify that, Senator, to not just basic research, because obviously I would carry it through to the application development, specifically to avoid having our industries have to do this redevelopment on an individual basis of common technology—what I would call the generic technologies.

Senator GORE. Right, I understand, and that is the classic American policy. Well, that is not accurate. That has been the classic statement of American policy for the last couple of decades.

It is not classic policy, because we had a Government-private partnership in building the railroads and the canals, and on and on, but now we pretend that it would be a serious mistake for us to have an organized national effort to stop the loss of the electronics industry.

If you found out that the new budget submission cut money to SEMATECH, would you react—whether you said it publicly or not, would your reaction be, "This is a terrible mistake?"

Dr. BROMLEY. As I said at the beginning, Senator, I really do not want to discuss the current budget process, but I will tell you that I—as I said in my testimony—support strongly the concept of SEMATECH and I can tell you without talking about any specific budget discussion that, were I involved in discussions where it was proposed that the SEMATECH support was being seriously cut back, I would do everything in my power to resist that.

Senator GORE. Good. That is a good, candid, forceful response. Now, beyond support for SEMATECH, what else, in concrete terms, what specifically would you recommend that we do to halt the erosion of America's semiconductor industry?

Dr. BROMLEY. I am afraid there, Senator, we really are getting into matters that are under active discussion right at this moment as part of the 1991 budget, and I cannot discuss them, sir.

Senator GORE. Oh, no, I am not asking you to reveal anything about the budget recommendations to the President.

I am asking you, as the President's science and technology advisor, what do you believe—specifically, what concrete recommendations would you make to halt the erosion of America's semiconductor industry?

You have stated support for SEMATECH. What else? Is that it? Should we do anything else?

Dr. BROMLEY. I think there are many things we should be doing Senator, and in general terms let me address them. They have already been mentioned both by you and by the chairman.

Senator GORE. Try to be specific, if you can.

Dr. BROMLEY. As soon as I become too specific, Senator, I am getting involved in this year's budget discussion and I cannot do that, but let me try.

Senator GORE. Well, I do not think that is necessarily true, but go ahead. Try.

Dr. BROMLEY. First of all, I think that the question raised first by Dr. Ross is an important one—the whole question of macroeconomic climate. We clearly can, should, and will work very hard in this administration to improve that climate, and that is under way at the moment.

Second, it seems to me that we can perhaps help as honest brokers, as stimuli, to get more vertical and horizontal integration within our own industrial complex. I hope that by doing that we can make it possible to make it economically sound for our semiconductor industry to maintain all of those critical components that were identified on Dr. Ross' chart in a productive, viable state within our own shores.

I think that there is a real call for greater cooperation, greater collaboration and vertical and horizontal integration in the industrial group itself.

Finally, as I said before, I think that we in the Federal Government have a responsibility and an opportunity to support what I call the development of the generic technologies. Of course, I am leaving out of this discussion completely what I know we both share, and that is the importance of keeping our science and technology base in a healthy, viable state because it is on that we build.

The three areas that I would focus on, sir, in response to your question, are, first, improving the economic environment in which the semiconductor industry and a number of our other high-technology critical industries work.

I would also try, second, to get greater cooperation, greater vertical and horizontal integration of our industrial folk working in this area.

Third, I would try to catalyze more aggressive development of the technologies that gave us, and continue to give us, our cutting edge in the competition in this field.

Senator GORE. Okay. Let us home in on that third item. You have said let us improve our general economic, macroeconomic strategy. Let us take a fresh look at vertical and horizontal integration. Then you said let us catalyze the development of key technologies; correct?

Dr. BROMLEY. Right.

Senator GORE. Not just basic R&D, but key technologies that are important in leveraging the success of manufacturing and the success of American participation in key industries.

Dr. BROMLEY. In areas where there is a consensus that they are important for our economic competitiveness or national security.

Senator GORE. Should the Defense Advanced Research Projects Agency (DARPA) support domestic HDTV?

Dr. BROMLEY. That is a specific budget question, sir.

Senator GORE. No, I am asking your opinion. I want to get to some specifics of your third point there, just right down the middle of that recommendation. I would like to know your view, not the budget, not what the President is going to say in the budget. What is your view?

Dr. BROMLEY. Let me avoid the budget discussion and tell you what I told you before, sir; that is, in the matter of HDTV, I have long felt, and I think you do, too, that the public discussion has been substantially beside the point.

The point is that a modern HDTV is not really distinguishable from a high quality workstation or a high quality personal computer. More to the point, the hardware and software inside those devices is the hardware and software that will be of great importance to the next generation of telecommunications and computers.

Senator GORE. We know that. I hope you are working toward an answer for the question.

Dr. BROMLEY. I am getting there.

The question of whether we should specifically support HDTV, per se, is one I would not comment on.

I am getting there.

Senator GORE. No, I think you missed your exit. [Laughter.]

Dr. BROMLEY. Not at all.

I believe that where we should focus is on that underlying hardware and software that is going to be part of the generic technology that is going to be important not just in HDTV, but in a great many areas. I would certainly personally support our helping to keep our research, and our technology, as strong as possible in those areas.

Senator GORE. Let me conclude my portion of this by saying I have deep respect for you, Dr. Bromley, and I appreciate your appearance here, but, honestly, the general views you express are not supported by the specific policies of the administration.

You are in a tough spot because I have the feeling that if you had your sea legs yet, if you had, in other words, been there a long time and knew the players and what your latitude was and were willing to come up here and lay out your specific recommendations for what we ought to do, I bet you would say, yes, DARPA ought to support domestic HDTV. But you are just not willing to say that yet.

DARPA has a wonderful track record. It is a tremendously successful illustration of what we can do when we home in on specific technologies. What is happening is the administration is letting all these things wither on the vine.

The statement of general support and general principles and then the cutting off of any specific actions that will implement those general views is very frustrating because what is happening

is the industry is being allowed to sink to whatever level is in store for it, regardless of the implications.

Anyway, I just wanted to express that frustration. I hope that we on this subcommittee can find a way to catalyze a different approach by the administration.

Thank you, Mr. Chairman.

Senator BINGAMAN. Senator Lott.

Senator LOTT. Thank you, Mr. Chairman. I would like to begin by commending you for calling this hearing in a very timely way, even though the Senate is in recess. I thought it was important that we have this hearing on an issue that involves the health of a very critical segment of our industrial base. Coming as it does at a critical time for the industry but also in the budget negotiations, I think it was very appropriate that we do this.

The semiconductor industries support both a significant part of our economic and commercial base, but also the technological superiority of U.S. weapons systems. So there is a great deal of significance here, and I am very, very glad to have this opportunity to hear this testimony today from three panels.

I would like to ask, Mr. Chairman, that my statement be made a part of the record.

Senator BINGAMAN. We will include it in the record.

[The prepared statement of Senator Lott follows:]

PREPARED STATEMENT BY SENATOR TRENT LOTT

Mr. Chairman, I want to commend you for calling this hearing on the timely issue of the health of a critical segment of our industrial base. The semiconductor industries support both a significant portion of our commercial economy and the technologicial superiority of U.S. weapon systems. A healthy, high-volume semiconductor manufacturing capability in the United States provides employment for our citizens and generates funding for the research and development in electronic systems upon which our national defense depends.

Over the last several years, we have received several studies documenting the erosion of U.S. market leadership in these strategic industries. In February 1987, the Defense Science Board released a report on the growing Defense Department dependency on foreign developers and manufacturers of semiconductors and the implications of this trend for our national security. As a result of the recommendations of that report, Congress authorized the establishment of the SEMATECH consortium, providing an unprecedented framework for Government-industry cooperative research. We have followed that initial commitment with approval of $300 million in Government funding since SEMATECH was authorized in 1987.

The most recent study by the National Advisory Committee on Semiconductors, which is the focus of today's hearing, is further evidence that the generally adverse trends for the U.S. semiconductor industries continue and that the American people stand to lose if those trends cannot be reversed. The report points to such factors as inequitable trade practices, the high cost of capital for U.S. firms, the shift of consumer electronics production from America to Asia, and the lack of full government support in the American business environment as the root cause of the U.S. decline.

Most importantly, the report makes a series of recommendations for action, which would involve the Congress and the executive branch to a significant degree if the recommendations were accepted. There would be substantial budget implications as well. As we face the formidable Gramm-Rudman deficit reduction targets next year, we must understand the short- and long-term cost and benefits of any such recommended actions.

Mr. Chairman, our witnesses today are well-placed to assist us in this endeavor. As Chairman of the National Advisory Committee on Semiconductors, Dr. Ian Ross will be able to discuss the committee's findings in great detail. Dr. Bromley and Mr. McCormack have long been involved with the efforts by the Federal Government to ensure adequate support for technology base activities in this country. I look forward to hearing their initial reactions to the National Advisory Committee study. Finally, Dr. Noyce and Mr. Kulicke are in a position to provide a report on the ac-

tivities of SEMATECH, which plays such a key role in the National Advisory Committee's strategy for revitalizing U.S. competitiveness in semiconductor manufacturing.

Senator LOTT. Dr. Bromley, thank you for being here. I enjoyed your testimony. You obviously have demonstrated skills in science and technolgoy, diplomacy and budget matters.

In view of the Senator's last question which you never got to respond to, let me give you an opportunity to speak for yourself on how the administration is doing with DARPA and with SEMATECH and the area in which you are working.

There have been some important things going on, and you are there in the position where you can try to influence that thinking. Have you any general comments you would like to make with regard to what we have been doing and how the budget discussions are going?

Dr. BROMLEY. I have to be rather circumspect, as you recognize, Senator, in my discussion of the budget matters because we really are in the final stages of closing up the budget. There have been all manner of unfortunate leaks already, and I do not want to start more rumors that are terribly counterproductive.

Let me simply respond by saying that I am very gratified both personally and on behalf of my office by the role that I have been able to play in these budget discussions.

The agreement that I worked out with Mr. Darman at the Office of Management and Budget is working, and I am involved in all the director's reviews at OMB that involve matters of science and technology. I have a real channel for input. I am using that channel. I will continue to do that as we go through the appeals process and finally close up the budget.

Senator LOTT. Let me ask you this specific question, then. It is not a question of whether or not the administration is committed to a number of these areas. It is a question of how and how much and how much is enough.

There are plenty of people here in the Congress who feel if we are spending $300 million it ought to be $600 million, and if it is $1 billion it ought to be $2 billion. It is not even a question of how much do we rationally need. It is let us get more than the administration asks for.

So we do have a commitment in these areas from the administration. Maybe we could use more money; maybe there is more we can do, and maybe we will. I don't think it is appropriate now.

Dr. BROMLEY. Let me say, sir, with respect specifically to the semiconductor industry and the questions that are being discussed in this report and in general that the administration certainly does appreciate the importance and recognizes the importance of the semiconductor industry in the areas that you have just listed. No question about it.

The problem that we face is that we have a wide range of proposed new initiatives of very high quality. The whole global change matter, for example, is one that is before the administration at the moment. There are new space initiatives. There are initiatives in the human genome area. There are a great number of these all competing for a very limited budget.

If we were to respond fully to the requests of any one of the competing sectors, as you recognize only too well, what we would end up with is very little left for the others.

The discussions that are going on right at this moment are balancing discussions, trying to do the best possible job for the United States as we see it within the total funding that you gentlemen feel you can make available to these areas in the coming year.

Senator LOTT. Having tried, perhaps feebly, to defend the administration's position and give you an opportunity to speak for it, I must say that this is an area where I think we do need more emphasis and more money, generally speaking, and I hope that you will use your influence, as I know you will, in that effort.

One question I have, for instance, I understand that there is a November 1989 study by GAO recommending that the Secretary of Defense forward to the President the names of seven individuals from industry to serve on the Advisory Council on Federal Participation in SEMATECH. There has been, I guess, some small delay in this.

Does the executive branch intend to act on the GAO recommendation soon?

Dr. BROMLEY. I do not know the details of this case, sir, but certainly I believe that there is no intention on anyone's part to in any way slow up SEMATECH.

Senator LOTT. I think that advisory council would be something that is worth looking into and something that would be worth having.

Dr. BROMLEY. I would be happy to look into it, sir.

Senator LOTT. One of the major issues involved with Government participation in SEMATECH has been the question of the balance between Government funding and the influence that Government should be able to exercise over the management of such a consortium.

On the one hand, we want to give the private sector managers relatively free rein to do what needs to be done. On the other hand, we want to make sure we are getting a maximum response from the funds that we are putting in it from the Federal standpoint.

What has been your experience with SEMATECH in that regard?

Dr. BROMLEY. I, sir, have not had that much detailed experience with SEMATECH at the working level, but let me say in general that I subscribe to a basic and, I believe, fundamental principle that has served this Nation extraordinarily well. It goes back to Emanuel Piore and Bob Conrad at the Office of Naval Research (ONR) in 1946. They said that if you want to do a job and you want to get the maximum effect from Federal participation in any activity, what you do is get the brightest possible person to run it and give him the least possible bureaucratic viscosity to work with and let him get on with his business.

In this particular case, I would find it very difficult to find someone more highly qualified than the present chairman of SEMATECH, and so my visceral reaction, sir, is that we should find the very best people we can and then we should turn them loose to do what they know better than any of us.

Senator LOTT. One last question. Looking to the future, how do you foresee the Federal Government's role in SEMATECH after the completion of the Phase 3 work scheduled for the mid 1993 period? Do you expect to terminate the Government's participation? Will SEMATECH go out of existence? Do you see it evolving, though, instead to new missions stretching into the future? What comes after SEMATECH, or do we keep SEMATECH and build on it?

Dr. BROMLEY. I do not know the answer to that at this point, Senator, except that I am quite convinced as a scientist that there will be new challenges, new problems, new initiatives, and new technologies that need to be developed if we are going to keep ahead of our competitors.

I foresee the kind of things that are going on at SEMATECH as being continuing activities that will be essential to keeping us at the forefront—where we really are now—of this industry.

Senator LOTT. Thank you very much, Mr. Chairman.

Senator BINGAMAN. Thank you very much.

Dr. Bromley, I do have another question or two, as perhaps other members here do. But before we go to a second round I would like to call on Mr. McCormack. In my enthusiasm to ask you questions, I did not allow him to give his testimony before the first round. I would like to call on him now to testify so that we can ask him questions in the second round of this panel as well.

Mr. McCormack is the Acting Deputy Under Secretary of Defense for Acquisition and is going to give us the Department of Defense position on some of these issues and on the report of the National Advisory Committee on Semiconductors.

Mr. McCormack, thank you for being here.

STATEMENT OF ROBERT C. McCORMACK, ACTING DEPUTY UNDER SECRETARY OF DEFENSE FOR ACQUISITION, DEPARTMENT OF DEFENSE

Mr. MCCORMACK. Thank you, Mr. Chairman and members of this committee. I appreciate the opportunity to discuss the following subjects as they relate to the Department of Defense's overall strategies: First, SEMATECH; second, x-ray lithography; third, the first annual report of the National Advisory Committee on Semiconductors; and last, the Department's strategy for manufacturing technology.

First on SEMATECH, the Department views semiconductors as an extremely critical technology. The prominence placed on this is exemplified by its prominent position on the recently issued Defense Department critical technologies list.

Equally important are the tools required to manufacture semiconductors. We recognize the strong semiconductor industry as dependent on a strong manufacturing base which in turn is dependent on a strong manufacturing equipment base. As I have stated previously, we fully support this. We have fully supported the establishment of SEMATECH and the continuing funding thereof.

With respect to the subject of x-ray lithography, this is a leading candidate for semiconductor geometries beyond the capacities and capabilities of the optical lithography currently in existence.

X-ray lithography offers distinct advantages and high-volume production of semiconductors with geometries currently produced with the optical systems. As Dr. Ross indicated, this is a window into the future, and we support research in this area and will continue to do so.

With respect to the National Advisory Committee's report, we generally concur with the findings thereof. I think Dr. Bromley has pointed out two areas of concern to the administration; namely, the establishment of the public electronics corporation and the minimum standards issue. The Department of Defense agrees with that position.

With respect to the DOD strategy for manufacturing technology, we are keenly interested in this. We have substantial time, money and people committed to furthering development in the manufacturing area, and I think the prospective trip that you are about to embark on, Mr. Chairman, will give you a window into some of our concerns as well as some of our interests in this area.

To remain a world leader, we need to be a world manufacturing leader as well. We definitely support the concept that in order for the Department of Defense to have a strong military industrial base, it is a prerequisite that we have a strong domestic industrial base.

That concludes my introductory comments, sir, and I have more extensive comments that I will submit in writing for the record.

[The prepared statement of Mr. McCormack follows:]

MR. ROBERT C. McCORMACK

ACTING DEPUTY UNDER SECRETARY OF DEFENSE (ACQUISITION)

STATEMENT ON

SEMATECH
X-RAY LITHOGRAPHY
NATIONAL ADVISORY COMMITTEE ON SEMICONDUCTORS REPORT
DOD STRATEGY FOR MANUFACTURING TECHNOLOGY

Mr. Chairman and Members of the Committee

INTRODUCTION

I'm Robert McCormack, Acting Deputy Under Secretary of Defense for Acquisition in the Department of Defense. I appreciate the opportunity to discuss the following subjects as they relate to the Department's overall strategies:

SEMATECH

X-Ray Lithography

The first annual report of the National Advisory Committee on Semiconductors

Department of Defense strategy for manufacturing technology

SEMATECH

SEMATECH was created in 1988 in response to the findings of tne Defense Science Board Task Force on Defense Semiconductor Dependency. The Task Force identified the decline of that the United States semiconductor industry was the leading cause of the increased dependence of United States weapon systems on foreign semiconductors. A joint Government-Industry consortium to develop and improve semiconductor

manufacturing technology was recommended by the Task Force to reverse the decline of the semiconductor industry and regain United States leadership in this critical technology.

The Department views the capabilities provided by advanced electronics, most of which are based on semiconductors, as the greatest force multiplier technology available to the Department for weapon systems. The prominent place that semiconductors hold on the Department's Critical Technologies List is evidence of this view. Of equal importance is the processes and tools required to manufacture semiconductors. The Department recognizes that a strong semiconductor industry is dependent on a strong manufacturing base which in turn depends on a strong manufacturing equipment industry.

The Department of Defense fully supported the establishment of SEMATECH and continues to support this important effort to strengthen the defense industrial base. The Department is fulfilling a five year commitment by providing technical and management guidance as well as funding to SEMATECH. The Defense Advanced Research Projects Agency (DARPA), as the representative of the Department of Defense and the Government, provides oversight and monitoring of SEMATECH programs. Under the Memorandum of Understanding between DARPA and SEMATECH, DARPA has appointed a Program Manager to review technical activities and monitor progress of SEMATECH programs. The Department has also assigned an Air Force officer to work on-site, directly with SEMATECH's technical staff. In addition, DARPA is currently establishing the means to transfer information on SEMATECH programs to all interested agencies within the Department and the Government.

X-RAY LITHOGRAPHY

The importance of semiconductor technology to the Department was indicated in the discussion of SEMATECH. The advance of semiconductor technology requires the extension of manufacturing capabilities to continually smaller geometries. Lithography is probably the most important element in semiconductor manufacturing.

Optical lithography, currently the dominant lithography technology, is expected to reach its practical limits within the next decade. X-Ray lithography is the leading lithography system candidate for semiconductor geometries beyond the capabilities of optical lithography. Futhermore, x-ray lithography offers distinct advantages in high volume production of semiconductors with geometries currently produced with optical lithography. X-Ray lithography systems provide more exact definition which enhances semiconductor yields thereby increasing productivity. Some experts believe that if x-ray lithography technology is perfected by our world competitors it will allow them to dominate the entire semiconductor market.

In comparison to our competitors, the United States effort in x-ray lithography is underfunded and has been uncoordinated. The Japanese investments to date have been reported to be about $700M. In the United States, IBM has provided the bulk of the funding. IBM has stated that it will invest $1B to bring x-ray lithography tools into a production environment. Congressional interest established a x-ray lithography project in FY88. DARPA now manages this program and is attempting to provide national x-ray lithography program coordination.

Continued Congressional support is essential to continue x-ray lithography research and development in the United States. Increased funding is also required to decrease the lead of our major world competitors.

NATIONAL ADVISORY COMMITTEE ON SEMICONDUCTORS REPORT

The National Advisory Committee on Semiconductors was formed to develop a coherent national strategy for semiconductors. In order to represent all views, the membership of the Committee was drawn from Government and industry. The Committee has met throughout the past year and issued its first report earlier this month. The report builds on other reports issued by the Department over the past several years; however, as mandated by the Congress, it focusses on developing a national semiconductor strategy. The Committee's report describes the decline of the United States semiconductor industry and identifies the root causes for the decline of this critical industry. Most importantly, the report contains specific recommendations to revitalize the domestic semiconductor and electronics industries.

The Department of Defense participated in the Committee's deliberations. Dr. Robert Costello, former Under Secretary of Defense for Acquisition, assisted in the early work and Mr. Alan Marty, Special Assistant to the Secretary of Defense, later represented the Department on the Committee.

The Department generally concurs with the reports findings. The Department will continue to support, as appropriate, the implementation of the Committee's recommendations, but industry has to play a major

role in this effort.

DOD STRATEGY FOR MANUFACTURING TECHNOLOGY

The Department of Defense recognizes that to control defense acquisition costs attention must be given to the process of building defense systems, not just the product itself. To this end DoD is investing in manufacturing technology developments in a number of areas. In recognition of the fact that electronic devices play the leading role in our present and future military capability, the major focus of our manufacturing technology efforts are in microelectronics. Semiconductor manufacturing technology is the number one entry on the DoD critical technologies list. Some examples of DoD investment include:

The Defense Advanced Research Projects Agency (DARPA's) Defense Manufacturing Office is currently funded at over $300M in FY90. Major programs are SEMATECH, Millimeter Microwave Integrated Circuit (MIMIC) and the X-Ray Lithography . The Defense Sciences Office of DARPA also has a major effort entitled Microelectronics Manufacturing Science and Technology (MMST). All of these DARPA programs are aimed at developing advanced techniques for the production of integrated circuits for military use.

The services continue to invest in improving our capability to produce high technology weapons systems. The Air Force's Manufacturing Technology Office has over a 30 year history of developing key manufacturing techniques and processes. The Air Force program is broadly based and addresses materials, structures and critical devices as well as

electronics. The Navy divides its development of manufacturing technology between a dedicated organization, at Naval Ocean Systems Center (NOSC), and the various production programs. The Army has a similar approach, concentrating some of its efforts through Army Material Command with the remainder through program specific resources.

DoD is deeply concerned over the availability and capability of a domestic industrial base to support military requirements. Our current investments in manufacturing technology related efforts exceed $500M per year. To remain a world leader, even in times of reduced tension, requires that the U.S. military have access to the latest technology. If the latest technology is not available from domestic sources, then we are not in a position to determine our future. The DoD supports the notion of a strong domestic industrial base for essential military technologies.

Senator BINGAMAN. Thank you very much.

Let me first ask Dr. Bromley an additional question.

You alluded earlier to the report that you were going to be working on in coming months for us here in the Congress, and I gather what you are talking about is the National Critical Technologies report and the establishment of that National Critical Technologies panel that we directed in fiscal years 1990–91 Defense authorization bill.

I would be anxious to get your elaboration on what is going forward with that and the timetable and anything else you would like to say about it.

I will just say in preface that I, for one, consider it a very important initiative. I think it holds out promise that we can have a national consensus on what some of those priority areas are that we need to give attention to and we need to maintain stable and appropriate and adequate funding for.

So with that biased preface, let me go ahead and call on you to say anything you would like about your views on it.

Dr. BROMLEY. That clearly, sir, will be an important part of our activity in the coming year in response to your legislation. What I had spoken of earlier, however, was something else; that is, that we committed OSTP earlier, in hearings before Senator Gore, in fact, to producing early in 1990 a draft technology policy, a more global technology policy, and we are working very hard at the moment in consultation with private sector groups, the Competitiveness Council, the Industrial Research Institute (IRI) and a variety of other groups to try to get the report to you as early as we can.

We welcome, beyond that, the opportunity to respond to your request concerning critical technologies because we agree with you that this is a very important area, and we welcome the opportunity to try to respond in the form that you have suggested.

My only reservation, sir, has to do with timing; I am still desperately short of staff in my office and, indeed, of the funding for those staff. We will certainly take on this task, and we will be most interested in doing it. My new Associate Director for Industrial Technology, who I hope will be confirmed by you and your colleagues shortly after you reconvene, will play a very important role in that; but so, also, will all the senior members of my office.

We look forward to the challenge that you have given us because we think it provides a vehicle for us to really examine a whole series of these critical technologies—both in the civilian and military sectors—at a level of detail and depth that we would not otherwise have the opportunity to undertake.

Senator BINGAMAN. Let me make one point, and then Senator Gore wanted to make a point. We recognize the shortness of resources and staff from which you suffer and accordingly put in this provision directing the Secretary of Defense to reimburse you, not exceeding $500,000, for the expenses you incur in doing this panel's reports.

Dr. BROMLEY. We deeply appreciate that, Senator.

Senator BINGAMAN. We are anxious that you call on him for that money, and we will certainly urge him to make it forthcoming.

Mr. McCormack, you might carry that message forward.

Dr. BROMLEY. Thank you, sir.

Senator BINGAMAN. Senator Gore wanted to make a comment.

Senator GORE. Very briefly, just so the record is crystal clear on this point, we have moved expeditiously in the science subcommittee to confirm all the appointees you have sent.

Dr. BROMLEY. Yes, that is correct.

Senator GORE. You say that you hope we will soon confirm the Technology Assistant, but you have not yet sent him up, have you?

Dr. BROMLEY. Absolutely, sir. I was not implying any delay on your part.

Senator GORE. When do you expect to be able to make that appointment?

Dr. BROMLEY. I am assured by all the people involved in the necessary bureaucratic processes that lie in front of the formal nomination being sent to you that those will be completed before you return, so that the nomination should be in your hands when you reconvene.

Senator GORE. Now when you talked about a shortage of staff, did you have in mind the two appointments that you have yet to make?

Dr. BROMLEY. The support staff that will back up those people.

Senator GORE. What is the delay?

Dr. BROMLEY. It is purely a budgetary matter.

Senator GORE. Money alone will not solve that problem, will it?

Dr. BROMLEY. That comment applies in a more global sense, Senator.

Senator GORE. I just wanted to know the breadth of application for your approach to the problem.

Dr. BROMLEY. We have just defined the grid size where it ceases to apply. [Laughter.]

Senator GORE. Okay. Thank you very much.

Thank you, Mr. Chairman.

Senator BINGAMAN. Let me ask Mr. McCormack a question. You indicate that DOD invests a significant amount, $500 million, in manufacturing technology. That is a significant amount, but it works out to about 1.5 percent of the total R&D budget of the Department of Defense.

There have been recommendations by the National Academy of Sciences for a significantly greater emphasis by DOD on process technologies and research related to process. Their point is to try to bring some balance between process and product technology.

Do you have any views on that?

In fact, I think one of the DOD reports this last year made a similar point and indicated a shortfall in what the Department of Defense has done in that area.

If you have any comments, I would be anxious to hear them.

Mr. MCCORMACK. Senator, the Department recognizes that there are considerable cost savings to be derived from having an integrated design development and manufacturing strategy presented in the beginning of a program or in new technology.

Again, I think on the prospective trip that you are about to take you will see real life examples of those. We recognize those, and there is an effort within the Department to focus on that. The whole subject of concurrent engineering is part of that, and the saving potential is very real. We do support that.

Senator BINGAMAN. Let me see if there are other areas that I need to ask about now. I could go on for a substantial length of time here trying to better define the difference between industrial policy and technology policy, Dr. Bromley, but I do not think that that particularly moves the ball.

I am encouraged by your statements of support for Government support for generic and enabling technologies in areas where the private sector does not have the incentive or the wherewithal to make the necessary investment. I think it is recognized, and I gather this was stated in one of your answers to an earlier question, that by virtue of the difference in tradition and difference in structure that we have in this country as compared to the Japanese, for example, we historically have relied much more heavily on Government to do much of the research that is needed to stay at the cutting edge of technology. That has historically been the case and will have to remain the case and perhaps even increase as we go forward if U.S. firms are going to be competitive.

I gather that was the position you took in your earlier comment. Did you have any other statement on that?

Dr. BROMLEY. No, I would not add to that, sir.

Senator BINGAMAN. Okay. I have some concern also about technology consortium. This is really the subject of another hearing which we will have after the first of the year, but since we have you here as a witness today, I would like to ask about your suggestion that we need to do more in the way of consortia to get industry and Government together in particular areas of focus.

There are several consortia going on in Europe today which I think are doing or are trying to do the very kinds of things that you are suggesting. The EUCLID project which has chosen 11 key technologies; EUREKA; the JESSI project; these are all projects that have come about fairly recently in Europe and seem to be trying to fill some of these needs which we are here grappling with in this hearing.

Do you have any comment on what is occurring there or whether that requires response?

Dr. BROMLEY. I probably do not have any more detailed information than you do, sir, on that; but I agree with you entirely.

What is happening is that as we come closer to EC-1992, the Europeans are moving aggressively and effectively to set up organizations that will allow them to obtain the maximum cooperative benefit from developing—up to the competitive phase—the kind of technologies, the kind of input that they are going to need to allow them to compete as formidable entrants in the world marketplace.

Senator BINGAMAN. As I say, that is the subject of another hearing, and we will be looking into that in more detail after the first of the year.

You have been most generous with your time, and we appreciate your willingness to come forward and give us your views and the views of the administration at this point.

The same with you, Mr. McCormack. Thank you very much.

We will dismiss this panel and call our third panel forward.

Mr. MCCORMACK. Senator, may I make a comment on the subject of high definition displays?

Senator BINGAMAN. Certainly.

Mr. McCormack. I think there has been some misunderstanding as to exactly what our objectives are and why we are doing it.

The point is that the Department of Defense currently buys high definition display panels at a cost of approximately $500,000 each.

Dr. Bromley has pointed out that from a technology standpoint, where that industry and business is going, it is hard to differentiate between those display panels and what you are going to see downstream for computer terminals as well as television sets. The technologies for these three industries are merging into one common function.

Our support for the high definition display technology is an attempt on our part to get the cost of those screens down from something in the area of $500,000 each down into the tens, possibly $20,000. Our attempt is not to start, incubate, support and finance the beginning of a high definition television industry.

There may be some technology that will spin off from what we are doing that will benefit that industry. As a matter of fact, I think it will, but that is not what we are starting with as an end-all objective. I think there has been a lot of misunderstanding on that point.

Thank you.

Senator Bingaman. Thank you for that statement, and thank you both for testifying.

Dr. Bromley. Thank you, Mr. Chairman.

Senator Bingaman. Dr. Noyce and Mr. Kulicke are the next witnesses. If they would come forward, please.

As a matter of introduction to Dr. Noyce's testimony, let me indicate that I know this has been widely reported, but just for the record I would indicate that he is the first recipient of the Charles Stark Draper Award given by the National Academy of Engineering. I think that is a singular honor which I just wanted to acknowledge once more this morning.

Dr. Noyce, why don't you go ahead and give us any comments you have, and then I will call on Mr. Kulicke before we have questions.

STATEMENT OF DR. ROBERT N. NOYCE, PRESIDENT AND CHIEF EXECUTIVE OFFICER, SEMATECH

Dr. Noyce. Thank you very much, Mr. Chairman. First of all, let me tell you that it is a pleasure to be here testifying on this subject. It is one that is near and dear to my heart, obviously. I have submitted some written testimony about the progress that SEMATECH has made. I would like to have that in the record.

Senator Bingaman. We will include your entire statement in the record.

Dr. Noyce. Thank you very much. With that, I am going to try to keep my comments here brief. I think that the interaction with the committee is actually more fun than sitting up here and telling you what is going on. We have reported that widely. It has been reported in a number of other reports as well.

I think the main thing that I would like to say is just simply that I think that the concept is working. We have really gotten a good and intelligent team put together from the member companies, and

from the Government. We are working hard to accomplish our mission, and I think that we are making great progress there.

One comment that I would make is that since the original concept of SEMATECH, which was 2 years ago now, the job has perhaps become a bit more difficult as has been well documented in the NACS report. The erosion of the infrastructure behind the semiconductor industry has accelerated in these past couple of years and consequently we are reorienting our programs to put more and more of our effort into supporting that infrastructure.

In particular, in this year out of our roughly $200 million a year budget, this year about $108 million will go into direct purchases from the supplier industry and in our joint programs with the supplier industry and our work with the universities on more advanced manufacturing research. We expect that number to reach $130 million next year for those kind of programs.

What I have heard here this morning is certainly very gratifying to me, the support for SEMATECH from DOD, from the science advisor and indeed from the NACS report. I firmly believe that this is the right way for America to go and I am glad to see that there is general agreement on that point.

Overall, I feel that the proper role of Government here is to enter into this spirited debate that is going on. We have heard that debate here today, about creating an environment in which American industry can thrive in a free enterprise mode.

The role of Government in encouraging precompetitive cooperation I think is valid. It is a concept which we have seen work in other countries, and indeed it has worked in America in the past, and I think it is one that we need to extend.

What I would like to see us do is turn our entrepreneurs loose and have them exist in an environment where they can indeed flourish. Today we are somewhat hampered in that, and the elements of our difficulties have been, I think, well-outlined in the testimony we have already heard today.

Certainly the issue of lack of competitive capital during this last decade, the real cost of capital, has by one report been four times as high as it was in the 1950s and 1960s and 1970s, when American entrepreneurism, American industry, was indeed flourishing.

We have seen the market access issues highlighted. In order to let America be competitive we certainly must have equal access to the world markets, as equal as our overseas competitors have to our markets.

Again, another issue that we have talked about is the need to rebuild our educational capability here in America, particularly in science and technology. It seems to me that the NACS report has been exhaustive. It has certainly been challenging to our thinking, and it gives us a basis on which to open the debate about the competitiveness of the semiconductor issue.

I would hope that we could move to an era in which our Government works more as a coach for American industry rather than a referee. If we look at the past history of America, when our primary competition was between American firms, indeed our Government perhaps had no interest in who won, so long as everyone played by the rules.

We are entering into a totally different era now, where the major competition for American industry is coming from overseas, and under those circumstances it seems to me that our Government should have an interest in the outcome of the game. It is to the benefit of the American people to have the American industry win in that competition, and I would hope that we can think in those terms as we think about the proper programs to support and undertake.

Finally, I would just like to comment that as SEMATECH was being established there was a great deal of concern that having SEMATECH overseen by the Department of Defense rather than, for instance, the Department of Commerce, might distort the aims of SEMATECH to satisfy primarily the specialized needs of the military rather than the broad support of the industry and consequently the broad support of the research upon which the military requirements are satisfied on that commercial basis.

I have to say that that has not been a problem for SEMATECH. We have had great support and help from DARPA, and I think that that agency has the capability of overseeing this kind of a cooperative venture, and that relationship is going extremely well.

So overall, I would say that the industry is supporting us, the Government is supporting us, it seems to be working well and we are doing the best that we can in order to go on with this job.

I will be happy to answer any questions and I think that will be the interesting part of this session.

[The statement of Dr. Noyce follows:]

PREPARED STATEMENT OF DR. ROBERT N. NOYCE

PRESIDENT AND CHIEF EXECUTIVE OFFICER, SEMATECH

Mr. Chairman and members of the subcommittee, it is my pleasure to meet with you this morning to discuss the progress of the Semiconductor Manufacturing Technology Consortium known as SEMATECH. I am also honored to have been included in such a distinguished list of panelists invited to testify before the subcommittee today.

I will focus my written testimony on the following four areas:

1. SEMATECH, with respect to its original plans, its approach and organizational structure, and its technology transfer activities;
2. SEMATECH's short- and long-term research goals and contingent strategies to handle potential changes in the semiconductor equipment manufacturing sector of the industry;
3. The time frame necessary to implement successful strategies to aid in the revitalization of the semiconductor industry, and;
4. Perspectives on other options for government encouragement of the industry.

SEMATECH: Plans, Organization & Technology Transfer

SEMATECH's mission is to provide the U.S. industry the domestic capability for world leadership in semiconductor manufacturing. Since its incorporation as a non-profit company in August 1987, SEMATECH has continued to fine tune its operating plans to let the consortium prioritize its resources for maximum impact. The SEMATECH Operating Plans submitted to the Defense Advanced Research Projects Agency (DARPA) for fiscal years 1989 and 1990, and subsequently transmitted from DARPA to the U.S. Congress, reflect the industry consensus gained at SEMATECH and the dedication of the industry -- in addition to the dedication of the men and women of SEMATECH -- in the pursuit of SEMATECH's mission.

Since SEMATECH is time-driven as opposed to profit-driven, we have focused our resources on three basic areas best accomplished by a consortium rather than an individual company:

-- Show stoppers, which are the critical tools and materials needed to be a world-class competitor in the semiconductor industry; further, these show stoppers are typically tools and materials that the United States is in danger of either losing technology leadership in or access to;

-- Key enablers, which are the tools and methods that would give the United States the largest competitive gains in the shortest amount of time;

-- High-risk, high-return projects which, by definition, are best done by a consortium rather than a single company due to the inherent risk involved in such research projects.

SEMATECH's organization (Figures 1 & 2) is designed to provide the flexibility and interactions needed by our engineers and scientists as we focus on the specific projects designed to accomplish our overall mission. Each project at SEMATECH has four distinct phases: definition, development, demonstration, and transfer to our member companies and DARPA (Figure 3).

Currently, SEMATECH has 57 projects underway. Eighteen are in the definition stage; 25 in development; and 14 in demonstration. To date we have conducted 41 workshops or seminars and two technology transfer sessions. These confidential meetings have been well received by our member companies and DARPA.

SEMATECH'S Short- and Long-Term Goals

SEMATECH is pursuing its mission in three initial phases. In Phase 1 we demonstrate manufacturing capability at the current level of technology, at circuit linewidths of 0.8 micron, using AT&T and IBM-shared production processes. The equipment and capabilities established in this phase are the basis upon which future generations of technology are built.

Phase 2 focuses on achieving manufacturing at the narrower linewidths of 0.5 micron, defines standards and specifications for chemicals and equipment, and demonstrates and transfers that knowledge to member companies and DARPA. At Phase 2, the U.S. will achieve semiconductor manufacturing parity in the 1991-92 timeframe with any competitor in the world.

Phase 3 targets the achievement of 0.35 micron manufacturing along with the associated standards. By achieving this goal in the 1993 timeframe, the U.S. should reclaim world leadership in semiconductor manufacturing. Subsequent phases are being defined at SEMATECH in order to extend and maintain our leadership by taking continuous advantage of technical breakthroughs.

While our Phase 1-3 targets are measurable and should be attainable, we must face the fact that the U.S. will not be able to maintain leading-edge semiconductor manufacturing capabilities without a competitive U.S.-based infrastructure. The equipment and materials industry in this country is falling prey to targeted efforts by foreign competitors determined to control the supply lines, the manufacturing, and the end products. In September 1989 SEMATECH gathered

information relative to the decline of our infrastructure. Since the U.S. has about a 40 percent worldwide semiconductor market share (Figure 4), we should expect at least a 40 percent market share of critical equipment and materials. That is not the case.

We found our position in wafer fab equipment (Figure 5), assembly equipment (Figure 6), and testing equipment (Figure 7) to meet the 40 percent test, although the trend lines foreshadow future problems. But when we looked into the critical equipment list (Figure 8) we did not find one equipment area that met the 40 percent test and seven of the 13 areas showed declining trends. In the area of critical materials (Figure 9) we found an even more dismal picture.

And as we surveyed our member companies and the members of Europe's JESSI consortium (Figure 10), we saw a steady deterioration in America's ability to compete effectively in leading-edge equipment and materials. Our member companies told us that as circuit widths decrease, spending on Japanese equipment increases and the same is true in Europe. I think the question for this industry and this nation is simply: Are we going to sit by and allow foreign competitors to control our destiny in such a critical industry? Clearly, without a competitive infrastructure the American semiconductor industry is squarely in harm's way.

SEMATECH is responding to this situation by dedicating the majority of its resources to revitalization of the semiconductor infrastructure. We will spend about $108 million this year on direct equipment purchases and joint development contracts. That figure will rise to about $130 million next year with the emphasis on joint development contracts and equipment improvement programs rather than direct equipment purchases for SEMATECH.

Our intent is to do everything we can with our limited resources to help create an environment that will allow our equipment and materials companies to maintain, sharpen, or develop a global competitive edge.

Revitalization Time Frame

The time for action is now. As America debates the public policy aspects of formulating a meaningful response to the realities of global competition we are literally losing our ability to keep pace. The demise -- or sale to a foreign competitor -- of a small American company that specialized in certain key materials or equipment may not seem important. But how many such firms do we have to lose before it becomes important?

SEMATECH feels that the loss of American competitiveness in the semiconductor equipment and materials industry warns of similar problems in the semiconductor industry itself.

Perspectives on Government Options

I have said on many occasions that SEMATECH is necessary but not sufficient. I would encourage the subcommittees and the Congress to explore avenues that would:

- restore U.S. education;
- encourage savings and the availability of capital for investment in new ideas, new jobs and new growth;
- and demand equal access to the markets of our trading partners.

Together these three areas would represent major steps in making America a more competitive nation, and if we cannot compete globally we are doomed to a declining standard of living. I feel it is necessary for Congress and the Administration to work with industry and academia to explore creative solutions on a problem-by-problem basis. We can no longer afford the confrontational policies and politics of the past. We must develop effective partnerships that will allow us to reach consensus and attack problems using American ingenuity and a can-do attitude.

As we work together in this country for the common good, let's not forget to maintain constant vigilance to ensure that the trading atrocities of the past do not occur again without swift and severe reactions by our government. It is often convenient for us to lay blame solely at the feet of our trading partners without realizing that we not only allowed such actions to take place, but we also had a hand in creating the environment that allowed such unfair practices as illegal dumping on the American markets and barring Americans from meaningful participation in foreign markets.

Insofar as specific recommendations are concerned, I would like to associate myself with the actions called for by the Semiconductor Industry Association (SIA) and the American Electronics Association (AEA) to address the issues of education, market access, and the need for savings and investment capital.

I think it's clear that America knows how to fix our current problems. The question is: Do we as a nation have will power to do so? I would hope as leaders in your districts, your states, and in this national body that you would use your influence and talents to bring these issues -- and solutions -- to the attention of the American people.

Summary

Again, Mr. Chairman, I compliment you and the members of your subcommittee for conducting these hearings. Acknowledgement of a problem is the first step toward confronting and solving the critical issues before us today.

The assault we have witnessed on American industry has been calculated, targeted, and successful. I do not believe we are merely passing through an economic cycle. I believe we are at a crossroads and the direction we choose will have lasting impact on our nation. We need to restore the environment in this country that allowed our free enterprise system to flourish. Government and industry can work together in this country for the common good. In this context, I would be remiss if I did not compliment Dr. Craig Fields and the fine men and women of DARPA. When SEMATECH was but a idea, many in industry felt the achilles heel of such an endeavor would be the lack of helpful cooperation from government. I can unequivocally state that DARPA has been an intelligent, dedicated and helpful partner. Working as partners rather than foes, industry and government can make a positive difference.

Together, we took a positive step with the formation of SEMATECH but SEMATECH is but a very small step. We need giant strides in order to become globally competitive.

Thank you.

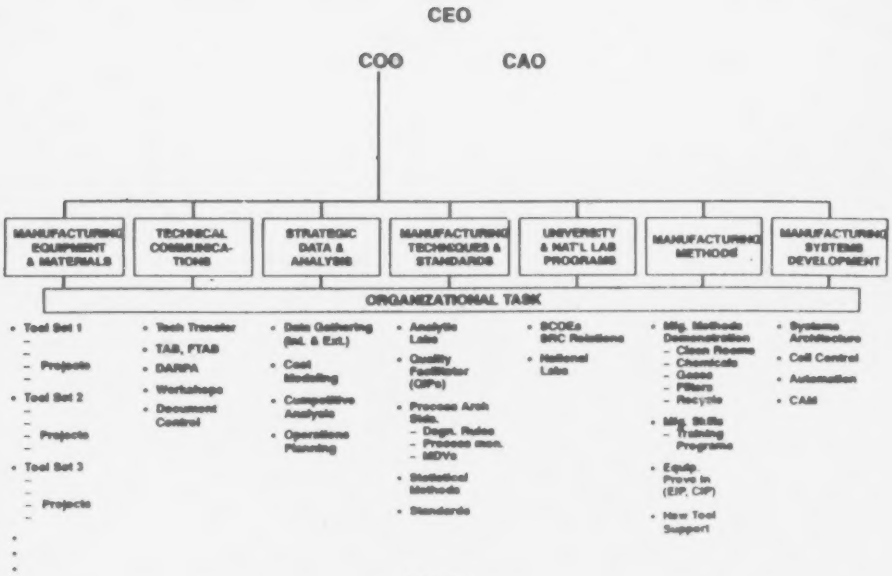

CEO
COO
CAO
MANUFACTURING EQUIPMENT & MATERIALS
TECHNICAL COMMUNICATIONS
STRATEGIC DATA & ANALYSIS
MANUFACTURING TECHNIQUES & STANDARDS
UNIVERSITY & NAT'L LAB PROGRAMS
MANUFACTURING METHODS
MANUFACTURING SYSTEMS DEVELOPMENT
ORGANIZATIONAL TASK
• Tool Set 1
– Projects
• Tool Set 2
– Projects
• Tool Set 3
– Projects
• Tech Transfer
• TAB, FTAB
• DARPA
• Workshops
• Document Control
• Data Gathering (Int. & Ext.)
• Cost Modeling
• Competitive Analysis
• Operations Planning
• Analytic Labs
• Quality Facilitator (QIPs)
• Process Arch Stds.
– Degn. Rules
– Process mon.
– MDVs
• Statistical Methods
• Standards
• SCOEs SRC Relations
• National Labs
• Mfg. Methods Demonstration
– Clean Rooms
– Chemicals
– Gases
– Fibers
– Recycle
• Mfg. Skills – Training Programs
• Equip. Prove In (EIP, CIP)
• New Tool Support
• Systems Architecture
• Cell Control
• Automation
• CAM

FIGURE 1

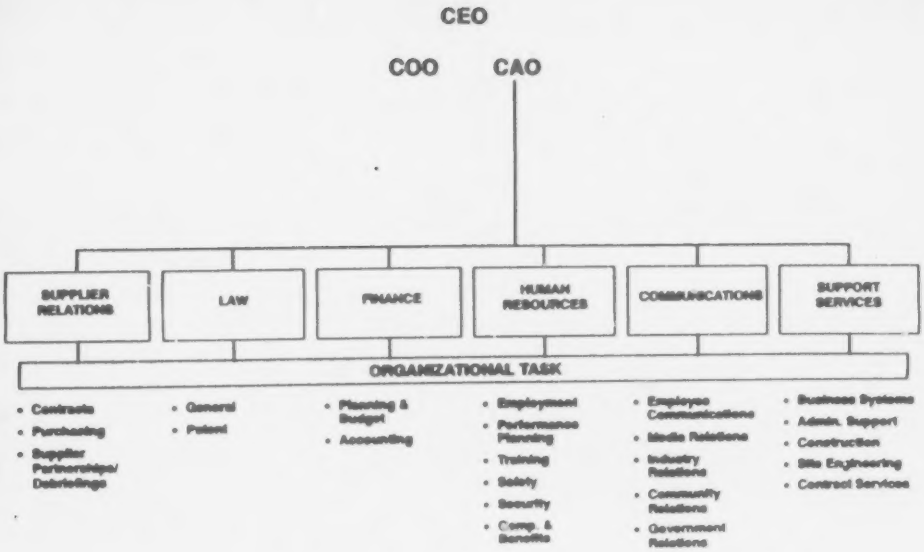


FIGURE 2

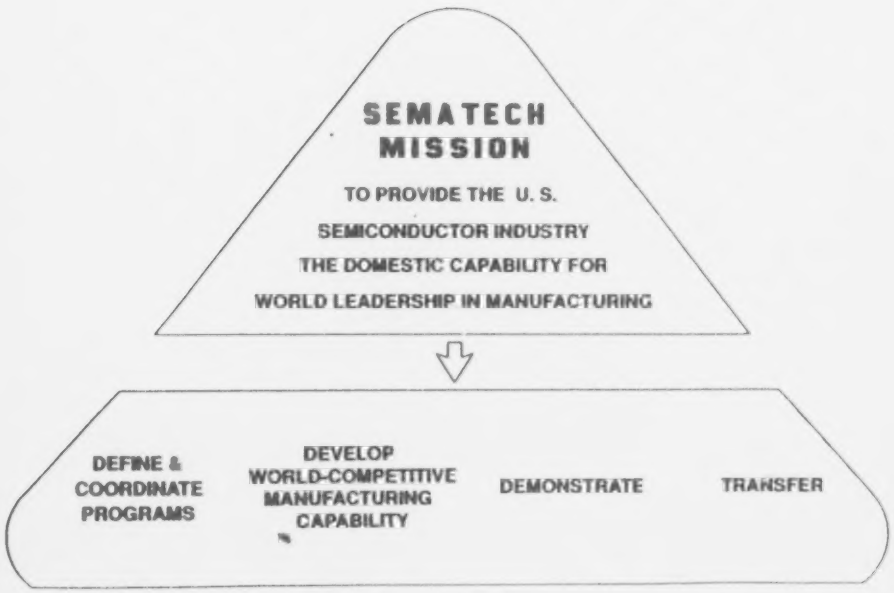
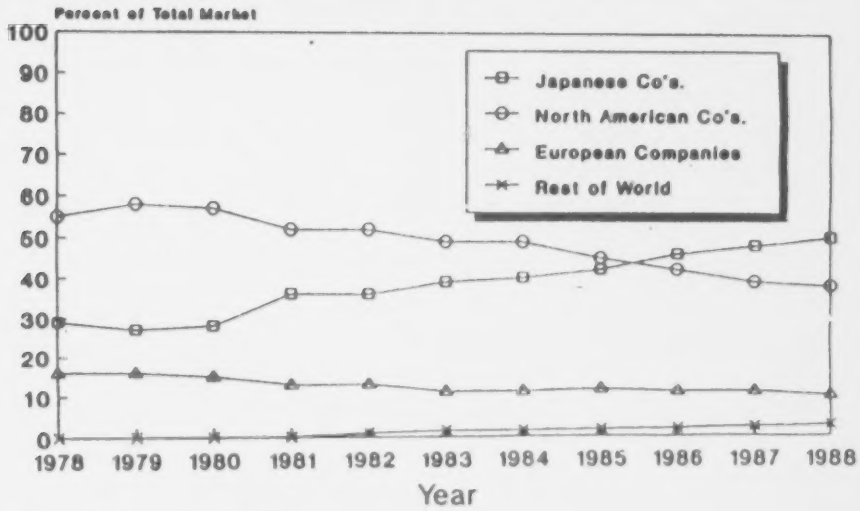


FIGURE 3

Worldwide Semiconductor Market Shares by Company Base

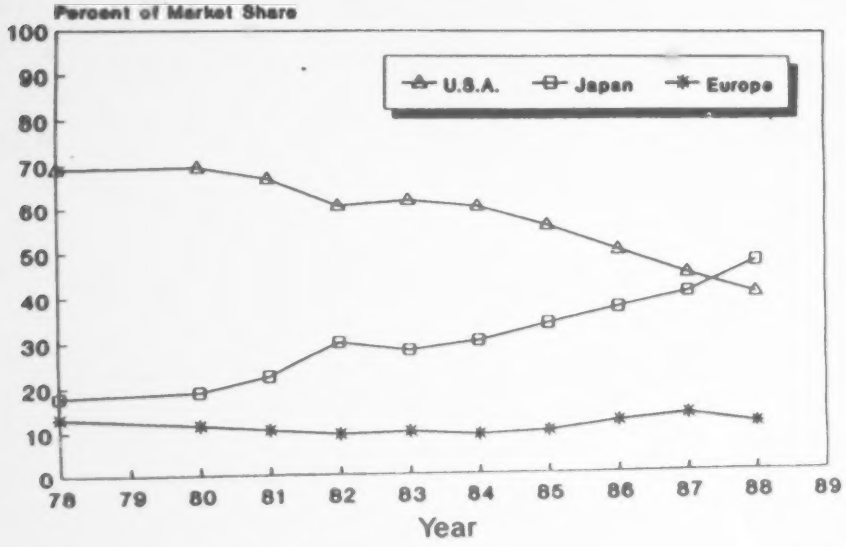
(Merchant & Captive)



Source: Dataquest January 1989

FIGURE 4

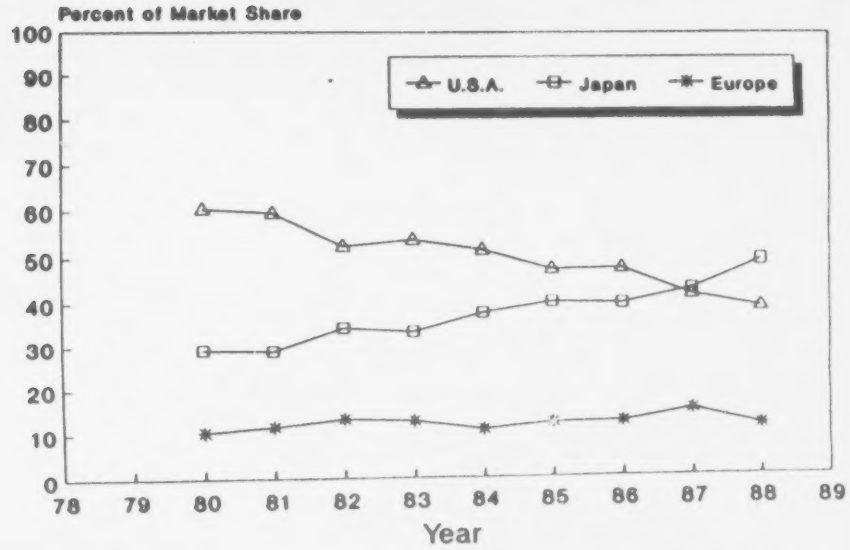
World-Wide Market Share
(Wafer Fab IC Equipment)



Source: VLSI Research

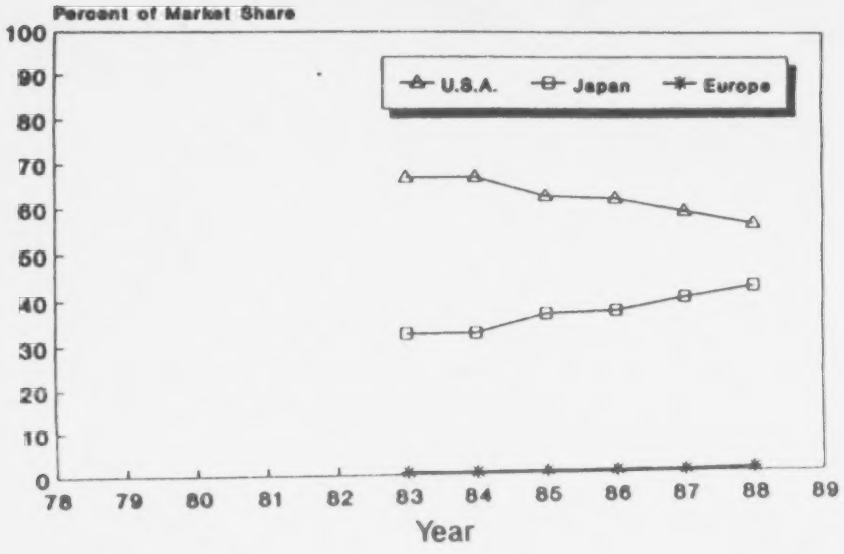
FIGURE 5

World-Wide Market Share
(IC Assembly Equipment)



Source: VLSI Research

World-Wide Market Share
(IC Testing Equipment)



Source: VLSI Research

FIGURE 7

Senator BINGAMAN. Thank you very much. Before I ask any questions, let me call on Mr. Kulicke, who is Chairman of Kulicke and Soffa Industries. He is a Director and Past President of SEMI, the Semiconductor Equipment and Materials International, and a director of SEMATECH. I gather he is here as a spokesman for SEMI, as well, of course, as offering his own views.

We are very pleased to have you here. Go right ahead.

STATEMENT OF C. SCOTT KULICKE, CHAIRMAN OF THE BOARD AND CHIEF EXECUTIVE OFFICER, KULICKE AND SOFFA INDUSTRIES, INC.

Mr. KULICKE. Thank you, Mr. Chairman. On behalf of SEMI and the 800 U.S. companies producing semiconductor equipment and materials, I want to thank you for this opportunity to comment on and to offer our support for the report of the National Advisory Committee on Semiconductors.

As the head of a company making semiconductor production equipment, I have witnessed first-hand the seemingly inexorable erosion of U.S. dominance in my business and that of my customers.

I can tell you from experience that it is no fun to be the target of multibillon dollar government industry effort such as Japan's Very Large Scale Integration (VLSI) program, or the many Japanese follow-on programs, or the more recent $4.2 billion JESSI initiative in Europe, and worse, it is not possible for the small, entrepreneurial companies that make up the U.S. Semiconductor Equipment and Materials Industry to succeed in the face of that kind of competition.

Before I go on, Mr. Chairman, I would like to make a point. These comments about competition, and especially about Japanese competition, should not be interpreted as Japan-bashing. In fact, I respect the Japanese for their ability to focus on an objective and to formulate strategies to achieve that objective.

In this case, their objective is to dominate the world's electronics business and their strategy is to target the semiconductor and the semiconductor equipment and materials industries, since they are the linchpin of all of the next generation of electronics.

The Japanese have obviously been successful with their strategy and have in the process rewritten the ground rules for this kind of competition between national economies. We no longer live in a laissez-faire world. We are increasingly seeing the European Community, as well as other newly industrialized economies in Asia, adopt the Japanese strategy, all at the expense of the U.S. electronics industry.

Korea is the latest example, with their recent announcement of a multibillion dollar program aimed at increasing the Korean equipment industry's home market share from a present 2.4 percent in 1989 to 50 percent in 1994.

I also believe it is important to remember in this context that the electronics industry is our country's largest employer and drives many other industries as well. Also, in spite of the damage that has been done to it, we still have the world's largest electronics industry based on our computer and telecommunications skills.

This means we have a lot left to lose still, but we also have a base from which we can fight back. This brings me to the NACS report. It is, I believe, a practical plan for an American counterattack.

We can no longer run our companies or our economy on a business-as-usual basis. Our semiconductor equipment and materials companies, which are rightly characterized as the core technologies of the semiconductor industry, are continuing to lose market share relative to our Japanese competitors.

Let me point out three specific problem areas. First, our semiconductor equipment companies are, on average, reinvesting a huge 17 percent of sales back into R&D to remain technologically competitive, but this spending, which is at the expense of current profits, when combined with the comparatively high cost of capital in the United States, has made us financially unattractive and we are unable to raise needed capital.

Second, the creation of next generation technology is an iterative process requiring close cooperation between users and vendors of semiconductor manufacturing equipment and materials. Buying these machines is not like buying a new dishwasher. You do not go down to the appliance store, buy one, have it sent home and plug it in. New equipment requires long qualification periods during which a machine is characterized and modified for a customer's specific process.

Unfortunately, the historically adversarial culture of our industry hinders crucial user-support of vendors during this period. The result is longer, more costly product introduction and debugging cycles and finally reduced competitiveness for user and supplier alike.

I would like to point out, Mr. Chairman, that it is in this area that SEMATECH is having its most immediate positive impact. We are glad of the work that Bob Noyce is doing for us here.

The third problem is that our customers—that is to say, semiconductor makers—continue to lose share to their overseas competitors. We are losing the ability to support a domestic equipment and materials base. As we lose that base, our U.S. customers are increasingly turning to overseas sources of production equipment and materials. While this tactic may offer them some short-term capability, in the long run it accelerates the industry's decline.

The undermining of the domestic equipment industry is immediate and obvious. Equally pernicious for our customers, though, is the long-term competitiveness problem created by their being dependent on their overseas competitors for production tools.

Given these three problems—financial unattractiveness, difficulty in cooperation and a declining customer base—it is not surprising that many of the equipment and materials industry's leading names, such as Perkin Elmer, are selling out while others are pursuing foreign alliances as the solution to these problems.

Mr. Chairman, I realize the problems of my $5 billion industry may seem like small potatoes compared to the issues you have to confront in this town. You may not worry if a few of us sell out, or go belly up, or otherwise exit the industry. But if this trend continues, our Nation's semiconductor industry, and ultimately our Nation's whole electronics competitiveness, will be undermined. Then

you will have a Washington-sized problem with both economic and national security implications.

The NACS report offers a way to avoid that eventuality. On behalf of our industry, I recommend the report to you. But rather than go into the detailed recommendations of the report, which have been discussed by the previous panelists, I would like to suggest a few broad principles which you should keep in mind as you evaluate the report.

The first is that you cannot help an industry that does not want to help itself. I believe the proposals contained in the report show that this industry is prepared to meet the Government half-way in the implementation of a national semiconductor strategy. That commitment is also demonstrated by industry's sharing of the cost of SEMATECH.

The second principle is that time is of the essence. As the committee reports, the longer we delay, the harder and more expensive it will be to rebuild this industry. I believe the onus is now on the Government, and by this I mean the whole Government—Congress and the administration alike—to respond to the report in a timely and constructive manner.

Third, I would point out that while the report is focused specifically on the semiconductor industry and its related infrastructure, many of the recommendations, especially in the business environment section, would in fact benefit all U.S. industry.

The last point I would make is that for these programs to work they must be supported by a national consensus that transcends partisan bickering or bureaucratic turf wars or interagency spats. One of the lessons our Japanese friends have taught us is that success in this sort of endeavor is based on a collective will to succeed. I hope that the NACS report will precipitate a debate that will lead to that kind of national commitment.

Thank you, Mr. Chairman, for this opportunity. I would be happy to answer any questions you might have.

[The statement of Mr. Kulicke follows:]

PREPARED STATEMENT OF C. SCOTT KULICKE, CHAIRMAN OF THE BOARD AND CHIEF EXECUTIVE OFFICER, KULICKE AND SOFFA INDUSTRIES, INC.

Good morning. My name is Scott Kulicke and I am the Chairman of the Board and Chief Executive Officer of Kulicke and Soffa Industries Inc, a major U.S. manufacturer of assembly equipment for semiconductor production. Kulicke and Soffa is one of hundreds of small U.S. companies that supply the needs of semiconductor producers. On behalf of Semiconductor Equipment and Materials International (SEMI), I want to thank you for this opportunity to comment on and offer our support for the report of the National Advisory Committee on Semiconductors.

As the head of a company making semiconductor production equipment, I have witnessed firsthand the seemingly inexorable erosion of U.S. dominance in my business, and in that of my customers, the semiconductor device producers. I can tell you from experience, it is no fun to be the target of a multi-billion dollar government/industry semiconductor research and development effort such as Japan's VLSI program, or the Japanese follow-on programs, or the more recent $4.2 billion JESSI initiative in Europe. And worse, it is not possible for the small, entrepreneurial companies that make up the U.S. semiconductor equipment and materials industry to succeed given that kind of competition.

Mr. Chairman, before I go on, I would like to make a point. These comments about competition, and especially about Japanese competition, should not be interpreted as Japan bashing. In fact, I respect and admire the Japanese for their ability to focus on an objective and to formulate strategies to achieve that objective. In this case, their objective is to dominate the world's electronics business and their strategy is to target the semiconductor, and semiconductor equipment and materials industries since they are the linchpin of all next generation electronics.

The Japanese have obviously been successful with that strategy and have in the process rewritten the ground rules for this kind of national competition. We no longer live in a laissez-faire world. We are increasingly seeing the European Community, as well as other newly industrialized economies in Asia, adopt the Japanese strategy, all at the expense of the U.S. electronics industry. Korea is the latest example, with their recent announcement of a multibillion dollar program aimed at increasing the Korean equipment industry's home market share from 2.4 percent in 1989 to 50 percent by 1994.

Mr. Chairman, I also believe it is important to remember in this context that the U.S. electronics industry is our country's largest employer and will drive many other industries in the future. Also, in spite of the damage that has been done to it, we still have the world's largest electronics industry, based on our computer and telecommunications skills. This means we have a lot to lose, but we also have a base from which we can fight back.

This brings me to the National Advisory Committee on Semiconductors (NACS) report. It is, I believe, a practical plan for an American counterattack. We can no longer run our companies, or our economy, on a business as usual basis. Our semiconductor equipment and materials companies, which are rightly characterized in the report as the "core technologies" of the semiconductor industry, are continuing to lose market position relative to our Japanese competitors. Let me point out three specific problem areas:

- First, our semiconductor equipment companies, on average, are reinvesting a huge 17 percent of sales back into R&D to remain technologically competitive. But this spending, at the expense of current profits, when combined with the comparatively high cost of capital in the United States, has made us financially unattractive, and unable to

raise needed capital.

- Second, the creation of next generation production technology is an iterative process requiring close cooperation between users and vendors of manufacturing equipment and materials. Buying semiconductor production equipment is not like buying a new dishwasher. You don't just buy these machines and plug them in. New equipment requires long qualification periods, during which a machine is modified for a customer's specific manufacturing process. Unfortunately, the historically adversarial culture of our industry hinders crucial user support of our vendors during this period. The result is longer, more costly product introduction/debugging cycles, and reduced competitiveness for user and supplier alike.

- Third, as our customers, that is to say the semiconductor device producers, continue to lose share to their overseas competitors, we lose the ability to support a domestic equipment and materials base. As we lose that base, our U.S. customers are increasingly turning to overseas sources of production equipment and materials. While this tactic may offer some short term capability, it accelerates the industry's negative trend. The undermining of our domestic equipment industry is immediate and obvious. Equally pernicious for our customers is the long term competitiveness problem created by their dependence on their overseas competition for production tools.

Given these three problem areas: financial unattractiveness, difficulty in cooperation, and a declining customer base, it is not surprising that many of the equipment and materials industry's leading names, such as Perkin Elmer, are selling their businesses, while others are pursuing foreign alliances as a solution to these problems.

Mr. Chairman, I realize the problems of my $5 billion dollar industry are small potatoes compared to the issues you have to confront in this town every day. The U.S. Government should not have to worry if a few of the members of my industry sell out, or go belly up, or otherwise exit the industry. But if this trend continues, our nation's semiconductor industry, and ultimately our nation's whole electronics competitiveness will be undermined. Then you will have a Washington-sized problem with both economic and national security implications.

The NACS report offers a way to avoid that eventuality. On behalf of our industry, I recommend the report to you. Rather than go into the detailed recommendations of the report, which have been discussed by previous panelists, I would like to suggest a few broad principles by which to evaluate the report.

- You cannot help an industry that does not want to help itself. I believe the proposals contained in the report show that this industry is prepared to meet the government halfway in the implementation of a national semiconductor strategy. That commitment is also demonstrated by industries' sharing of the cost of SEMATECH.
- Time is of the essence. As the Committee reports, the longer we delay, the harder and more expensive it will be to rebuild this industry. I believe the onus is now on the government, and by this I mean the whole government, Congress and the Administration alike, to respond to the report in a timely and constructive manner.
- While the report is focused specifically on the semiconductor industry and its related infrastructure of equipment and materials producers, please keep in mind that many of the business environment recommendations would, in fact, benefit all U.S. industry.

- For these programs to work, they must be supported by a national consensus that transcends partisan bickering or bureaucratic turf wars or interindustry spats. One of the lessons our Japanese friends have taught us is that success in this sort of endeavor is based on a collective will to succeed. I hope that the NACS report will precipitate just that kind of national commitment.

Thank you Mr. Chairman for this opportunity to offer my industry's views of the National Advisory Committee's report. I would be happy to answer any questions you might have.

Senator BINGAMAN. Thank you very much.

With regard to semiconductors, I think we have had a lot of discussion about the importance of them over the past several years now. That debate began at the time we set up SEMATECH.

Let me just ask the basic question again, though. As it relates to semiconductor equipment and materials, we have this chart in the report that I referred to earlier, figure 10, on page 13, which shows for 1988 the percent imported in both equipment and materials, and it is well above 80 percent in almost all cases and about 90 percent with regard to a lot of the materials.

Why is that a problem? If in fact as you say Mr. Kulicke, some of the firms go out of business and we become more and more dependent upon foreign sources for this equipment and for these materials, what is the problem?

We are dependent upon foreign sources now for most of our consumer electronics products. What is the major problem in us becoming dependent upon foreign sources for these items as well? I would like your views, or Dr. Noyce's—either one.

Mr. KULICKE. We see increasing evidence that as you become dependent on foreign sources, those foreign sources hold back the latest and greatest technology. Photolithography equipment, the sort of equipment Perkin Elmer makes, is one very prominent example where the latest generation Nikon steppers have not been available to American suppliers, while they have been available in large quantities to Japanese users. This, in turn, puts American semiconductor makers in a non-competitive position, because they do not have the most effective tools.

It is that availability of latest and best technology that is the driving issue behind foreign dependence.

Senator BINGAMAN. This latest, state-of-the-art equipment that you are talking about not being available is supplied by several vendors. Even if they are not U.S. vendors, is there not competition between them which would result in them making it available as soon as they have it?

Mr. KULICKE. It has not always worked out that way.

I would also remind you that this is an industry characterized by boom cycles. And when you get a boom cycle, the Japanese economy will more than absorb everything that is available, leaving nothing for the rest, and the rest being American users.

Senator BINGAMAN. So you are saying that, in your view, there have not only been examples of this technology being held back for a period of time, but there are periods where it is just not available at all to U.S. firms because the demand overseas is great enough to fill the supply. Is that what you are saying?

Mr. KULICKE. Not available in the quantity that American users would like to get it, yes.

Senator BINGAMAN. Dr. Noyce, did you have any comment on that?

Dr. NOYCE. I would concur with that.

We recently have been trying to do a survey of availability of Japanese equipment in some of these areas. And in particular, I would note that in response to a direct question at a conference in Hawaii recently, the man responsible for exporting the Nikon steppers to America was asked directly when the Nikon model, what-

ever the latest and greatest, would be available in America. The response that was recorded was, "When appropriate."

We feel a little uncomfortable about that.

One of the areas that I might comment on, regarding the materials, is that the materials research tends to go to where the materials are produced. Let us take silicon for an example.

We still have much of the silicon supply resulting from Monsanto actually being produced in the United States. That is not quite so bad. It was bought by a European firm, and they are indeed producing it in the United States. Consequently, the research is being done in the United States, and they are working with U.S. suppliers.

In many of the other cases, though, the tendency will be to work with the overseas suppliers. They will have the leg up. They will know what the capabilities of those materials are before the American producer will.

And it is that kind of a situation that we are concerned about.

I might just comment along this line that we have been having some conversations with JESSI, the European consortium. And in particular, where there is only a Japanese supplier, a better choice than that would be to have both a Japanese and a European supplier.

And so we are letting our people work with the JESSI people in defining those areas in which it would be advantageous to have a European supply as well as a Japanese supply, and get at least that kind of a competition.

When the competition has come up between the Japanese companies there is much more tendency for the Japanese companies to cooperate for their own national advantage versus their own company advantages in competing for overseas markets.

So there is a little bit of hesitancy there, even in spite of the fact that there might be two suppliers in Japan, to count on one of those two suppliers.

Senator BINGAMAN. One of the suggestions Dr. Bromley made on the Perkin Elmer situation was that U.S. firms, especially the customers to Perkin Elmer, might find it in their interest to join together and buy the semiconductor equipment division of that firm.

Why is that not a viable option, or is it? Is that something that could happen, that Government could encourage to happen? What is your view of that, either one of you, Mr. Kulicke?

Mr. KULICKE. I think you have got to look at Perkin Elmer as a symptom of the problem, not the problem itself. Before Perkin Elmer it was MRC and Micromask and Monsanto. And after Perkin Elmer, it will be another company and another company.

I think the underlying problem is that we have created a business environment in this country where companies like Perkin Elmer, and my own company for that matter, are only marginally financially viable, given today's environment.

You can maybe save Perkin Elmer. Maybe the Government can huff and puff and scare the Japanese away, but you have still got a company that is not financially viable in this environment. And so it is with a lot of our companies.

And that is the issue I think that public policy debate has got to be around.

Senator BINGAMAN. If that is where the debate should be, what realistically can we do, other than bring the cost of capital down to 4 percent? What can we get done here in the next session of the 101st Congress to deal with the core problem you are describing?

Mr. KULICKE. You have got cost of capital issues, you have got antitrust issues, and the Perkin Elmer case illustrates an antitrust problem. There is another American supplier of photolithography equipment, General Signal.

For General Signal to buy Perkin Elmer would be an antitrust problem. For Nikon, which is much bigger than General Signal, to buy Perkin Elmer, that is not an antitrust problem. We have those kinds of absurdities in the antitrust laws, which are hindering consolidation in this industry.

The cost of capital is a very obvious and striking issue, which is also a very thorny issue. I think some of the other, what are classified as business environment recommendations in the report, go to the underlying problems.

Senator BINGAMAN. Dr. Noyce?

Dr. NOYCE. Let me give you an example on a previous sale here of MRC to Sony. There was a study group going on to buy MRC. It had been on the market for some time. My understanding is that it was determined to have, with the discount rate in America, a value of roughly $8 a share, and an offer was forthcoming at that point.

Sony found out about it and basically said if it is worth $8 a share to an American with his discount rate, it is worth $13 a share to a Japanese with the Japanese discount rate, and went ahead without doing any due diligence beyond that, and made the offer and it was accepted.

Similarly, the same thing I think is true for Perkin Elmer. That whatever it is worth to an American company, with the requirement for more investment in it for the next generation of equipment, et cetera, it will be worth more to the Japanese company just simply because their discount rate for future earning stream or future cash flow is less.

I have one thought here that I might expose, and it is perhaps a little wild. But if we would look at Perkin Elmer, much of the technology that exists in Perkin Elmer has been paid for by the American people for the benefit of Americans.

It seems to me that if we are going to sell that kind of an entity to an overseas owner, what we ought to demand is that the Government get repaid for the investment that they have made in that kind of company.

If that were done, it would be attractive to sell that company to an American consortium. And indeed there have been groups put together that have tried to make an offer for Perkin Elmer. Perkin Elmer has considered them to be not adequate and they would be able to get more selling it to other entities.

In all fairness, Horace McDonnell has steadfastly maintained—he is the President and Chairman of the Board of Perkin Elmer—that he wants to sell to an American entity. And it just simply may be that in the dual role as an American and as fiduciary—knowing his fiduciary responsibilities to his stockholders, the question is, who is going to sue him when he sells for less than he could get for it by selling it to an overseas entity?

Now, if we were to request that an entity like this repay the Government for their investment in it, if it were to be sold overseas, then I think it would balance it out.

I might mention that SEMATECH was in the process of starting to negotiate with Perkin Elmer at the time—actually we started that process the day before he announced that he was going to sell it. We had on Perkin Elmer's desk the contract to do some joint development work with them, but it had a strange clause in it. And that clause was that if it were sold to an overseas investor that they would repay us the funds that SEMATECH had invested in the latest developments.

That contract was never signed by Perkin Elmer; it was signed by SEMATECH.

So, I question whether there has been a serious intent to sell it to an American entity.

Senator BINGAMAN. Is there any U.S. Government legal right in the technology that Perkin Elmer has that Government research dollars have helped to develop? Would you think there would be any legal right?

Dr. NOYCE. I do not know what the situation is on that, Senator.

Senator BINGAMAN. Let me ask about the suggestion in this report of the National Advisory Committee on Semiconductors that SEMATECH have its mission broadened, and that you take on additional responsibilities. I would like your thought as to what additional responsibilities would be appropriate for SEMATECH to take on? And, to the extent that there are additional responsibilities, what kind of additional cost would you be looking at?

Dr. NOYCE. As I said in my opening statement, I think that the job that we have to do has become somewhat more difficult in the 2 years that have passed since the original plan was put out.

As a result of that, we have been moving our emphasis to the semiconductor equipment and material suppliers, because we see that as more critical now than the job that we were going to do in the manufacturing technology, manufacturing methods, quality methods, the techniques, if you will, of high-volume production.

With more money, I think that we could accomplish more of the original job that we had undertaken. However, we feel that the support of the infrastructure is absolutely essential, and it is just going to take more support than we originally had expected. With more money, we could do both of those jobs.

Senator BINGAMAN. I have a general concern that I have discussed with you before, Dr. Noyce. When you look at this sample food chain whether you call it a food chain or a cluster of industries or whatever, it seems as though we are always finding particular areas that are under siege and trying to do something or provide some governmental support to shore them up. We are always sort of running behind. And perhaps that is what is happening with Perkin Elmer.

Does there need to be a place somewhere, industry, Government, somewhere, that tries to oversee the cluster of industries that relate to information-processing technology. Do we need a place that could be an early-warning system and could say, "this is an area of concern, and recommend appropriate action so that we are

not just waiting to read the morning paper to see what the latest problem is?"

Dr. NOYCE. It is certainly a lot more fun to start by building, rather than by saving drowning entities here.

And I think the kind of approach that Dr. Bromley was talking about, technology policy, what is going to be critical for the future and try to build the base under all of those, is a far more fruitful way to go.

In some ways it may be the equivalent of starting a small company. When you start a small company what you hope to do is to find a technology node, a change in direction where you can start at that point and you do not have to compete, then, with well-established, large entities, so it is cheap to do.

It becomes much more expensive to rescue a dying man here than to prevent him from getting ill in the first place. And maybe that is really what we are talking about.

So I think that we can identify crucial enabling technologies for the future and get into those. That will be cheaper than trying to do the other job.

Now, as Scott Kulicke was saying, we still have a substantial industry in America upon which to rebuild if we have the right environment. I am concerned that if we let this environment erode even further, the job of rebuilding will become prohibitively expensive.

Then we ask what America will supply to overseas markets in order to pay for all of our imports? Or will we simply have to stop all of the imports, with the implication that that has for the American consumer?

After all, somehow we have to pay our bills. And the easiest way to pay your bills is with something that the customer cannot get anywhere else.

Senator BINGAMAN. Is there a confluence of these technologies, particularly focused on the materials area? One of the things that DARPA has funded at a high level is research about advanced materials.

Is there a point at which if we lose a lead in advanced materials, are we then inevitably and irrevocably dependent upon foreign sources for the subcomponents that are essential to the semiconductor and the electronics industry as well? Or is that extrapolating too far?

Mr. KULICKE. I would make two points, Senator.

First, to go back 15 years ago, the Japanese had zero share in any of these businesses. So they have proved it is possible to come from nowhere. But they have done it at great cost and as a result, of great commitment. And the longer we wait the higher our cost will be and the most commitment will be required.

No, I do not believe you get to a place where you cannot recover. But I think it gets exponentially more expensive to recover as you wait.

Dr. NOYCE. The other comment I would make there is that we have ofttimes done the advanced materials research, it has been done in our universities and in our industries, but at the time of production, because of the business climate in America, it has been advantageous to source it overseas.

And that can only be attacked by looking at the business climate in America.

After it has moved overseas, there has been the tendency for the overseas entities to buy up the entire source of supply. But, as I say, the original ceramic packages were done in America, the original silicon purification was done in America, et cetera. And you can go right down the line on those.

But it has been moved overseas because it has been more competitive there.

As we think of America, I think maybe we should think of it sort of like recruiting football players to the University of Texas. Since I am now a Texan, I am a little bit more familiar with that. We try to get, in Texas, the best football players we can. We do not always succeed. But if you are not trying, you are not going to win the football games either.

We need to make it attractive for these industries to be here in America.

Senator BINGAMAN. Let me ask about gallium arsenide. This is one of the critical technologies that DOD identified in their report earlier this spring. I think they indicated, and others have, that this is the next generation of compound materials that will be essential for semiconductor production.

Do either of you have views as to what we need to be doing in that area?

It seems from what I have read that we are in real danger of losing whatever lead we have ever had in that area. Perhaps we have already lost it.

What, other than just continuing to support research, should the Federal Government do?

Dr. NOYCE. Again, gallium arsenide research was originally done in the United States and has moved overseas.

Gallium arsenide provides higher speed logic circuits for supercomputers and that sort of thing.

This has moved overseas in part, I think, because of the lack of vertical intergration in America. The supercomputer companies in America were not making their own semiconductor devices, the Crays, for instance.

That has been different in Japan.

Making gallium arsenide in small quantities is difficult. It costs a lot of money. You almost need to have the profit of the supercomputer sale put into the pot in order to support that gallium arsenide research.

The only way we have had to support gallium arsenide research in America, as a result, has been the military in some of the extremely high frequency applications in the military, the microwave integrated circuits, et cetera. We have had programs like MIMC (Microwave/Millimeter Wave Monolithie Integrated Circuit) to address those, and that is what has been keeping the gallium arsenide business alive and in the main in America.

We can do the job. The gallium arsenide applications will not take over the vast bulk of the semiconductor applications, but only that top fraction of 1 percent in the super high-speed computers.

If we are interested in the super high-speed computers, we need to support that directly, I think, and that will, in turn, support the gallium arsenide work.

Mr. KULICKE. From an equipment point of view, equipment for processing gallium arsenide is a very specific niche business that is not financially viable on its own.

Companies can participate in it only as an offshoot of their much larger business volumes in silicon processing equipment, and if you don't have silicone processing equipment, you will lose the gallium arsenide technology inevitably.

Senator BINGAMAN. Do either of you have a comment on this recommendation in the report on a consumer electronics capital corporation? If you do, I would be anxious to hear those.

Dr. NOYCE. First of all, I would just like to comment that what we are looking for in America is a way to let free enterprise flourish. That has been severely impacted in the last decade as we have steadily moved that kind of application overseas.

Now, the problem that I see there is that inventiveness can flourish anywhere in the world. But if you are not working on consumer products, you are not going to be inventive in consumer products either. You will be inventive in Apple Computer or IBM addressing the problems that our inventive people are working on.

So if we could get the environment right, as we come to a change in what is going on in consumer products, and I think that change is going on here with the high definition systems coming along, the merging of computers and information systems, et cetera, then I think there will be opportunity for an entry. But it cannot be done if the cost of capital is significantly higher here or the regulatory enviroment is significantly less friendly to that kind of activity.

It will require the cooperation between the computer folks, the display folks, the communication folks, and so forth. If we can pull those entities together in a cooperative venture, I think we may have a chance.

Failing that, the concern I have is, as Dr. Bromley said, we exported $200 billion worth of electronics last year, but we still ran a significant negative trade balance in electronics because of the consumer products. If we do not make our own, we are going to have to pay for those imports with something else, and I don't know what it is that we are going to have to pay for them with.

Mr. KULICKE. Real estate, assets, companies.

Dr. NOYCE. Yes, more Rockefeller Centers.

Mr. KULICKE. Yes.

Senator BINGAMAN. More Rockefeller Centers.

Mr. KULICKE. I would add one other thing to that. Reducing the cost of capital is a necessary condition. But in my discussions with potential players, specifically in the HDTV area, one of the things I sense is a complete lack of confidence in the usefulness of our trade policy; that if you dumped out of consumer electronics in the 1960s, and dumped out of DRAMs (Dynamic Random Access Memories) in the 1970s, and 1980s, just lowering the cost of capital is not going to be enough to solve that problem. You have to give people some sense of confidence that they can succeed.

Dr. NOYCE. One of the great advantages of the VLSI project in Japan, and I think it is one that we should look at carefully, was

the announcement in effect that the Japanese Government, in supporting the VLSI project, was going to assure the success of the investments in that area.

Now, this is a characteristic of Japan, that when they decide to do something, the entire society agrees that they are going to succeed at doing that.

If we could get the same kind of belief on the part of our investors in America, I think they would invest in HDTV systems. But, as Scott says, the environment is just the opposite. They believe that the Government will not support them in that effort and that they will allow the dumping to put them out of business.

Senator BINGAMAN. We have a great many other subjects that we could go into with questions here. But I think we have explored the main issues and I think it has been a useful hearing.

I appreciate very much the testimony, Dr. Noyce and Mr. Kulicke.

We will conclude the hearing at this point. When we get into the new year and get some more specific suggestions or proposals for action by the Congress, we will call on you again for your views.

Thank you very much.

The following is a prepared statement by Senator Lloyd Bentsen that I would like to insert into the record.

[The prepared statement follows:]

PREPARED STATEMENT BY SENATOR LLOYD BENTSEN

Mr. Chairman, I congratulate you on arranging this very timely and important hearing. I only regret that previous commitments in Texas make it impossible for me to attend in person.

Many of us in the Congress have been greatly troubled by recent reports that the Administration may be planning to abandon some of the advanced technology initiatives being pursued by the Defense Department, including the Sematech consortium in Austin and very promising research programs by DARPA (Defense Advanced Research Projects Agency) into High Definition Television (HDTV).

From what I hear, some economic ideologues oppose any government/industry partnerships; some defense planners oppose funding research in the Pentagon budget which promises major benefits for our economy as well as our security; and everybody is concerned about eliminating from the budget all but the most important programs. These various factions have led to a policy vacumm in the Administration.

The longer we watch and wait, however, the more erosion we are likely to see in our technological position, our economic competitiveness, and ultimately in our security.

The tidal wave of economic power now sweeping across the Pacific poses one set of challenges to us. And the political earthquake shaking Eastern Europe requires us to re-examine our most basic security policies.

I think that it is myopic and dangerous to ignore economic strength and industrial competitiveness when trying to assess a nation's security. To be strong, we need a sound economy and a well-educated citizenry as well as advanced weapons.

But even on narrow defense grounds, I believe the case for Sematech and related high technology initiatives is clear and compelling. As the General Accounting Office (GAO) and other investigators have reported recently, Sematech is a success already. It deserves the continued Federal contribution—which is being matched by the private sector. That means that the Pentagon is getting a bargain—doubling its effort in what it previously identified as the number one "critical technology" to assure the superiority of our weapons.

If the Government were to back out now, for ideological or budgetary reasons, it would force America into an unhealthy dependence on foreign sources for the basic building blocks of advanced weapons. That dependence would drive up our own costs and increase our future risks.

If we are entering an era of sharply declining defense budgets, we have to seek efficiencies wherever possible. What better efficiency is there than to have private

industry pay half the costs of research on a key component of weapons and vital supporting equipment like communications?

If the Soviet Union appears less threatening, then we had better use the opportunity to prepare ourselves for those many other threats to our security—in other regions and from other sources, like terrorists. And if we can afford fewer weapons systems, we should be sure that they are the most reliable and effective ones we can get.

That means relying on our special strengths, including advanced technologies. We shouldn't surrender our leadership—at least not without a fight. I cannot believe that America would walk off the field before the game is over simply because the competition is fierce.

We shouldn't accept dependence on foreign suppliers without careful consideration of the risks. For who can predict where the next political earthquake may strike, or where longstanding policies of friendship toward America might be reversed?

We should have a coordinated Government approach to these issues, for the most important are the dual-use technologies like semiconductors.

As a member of the Commerce Committee, I have been working with Chairman Hollings and others to strengthen our civilian research efforts in these promising technologies. But I want to emphasize to this Committee, given its oversight responsibilities, that continuing federal support for programs like Sematech is vital for our national security.

[Whereupon, at 11:45 p.m., the subcommittee adjourned, to reconvene upon the call of the Chair.]

24-892 (136)